TIWEST

We add value

Operations Manager - TIWEST Pty Ltd (ABN 59 009 343 364)
Joint Ventures between a subsidiary of TRONOX WESTERN AUSTRALIA PTY LTD (a subsidiary of Tronox Incorporated) s to a several interest of 50% and subsidiaries of EXXARO SANDS PTY LTD (ACN 002 376 847) as to a several interest of 50%

Dongara Mineral Sands Project

EPA Scoping Document for Public Environmental Review

10th May 2010

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1. INTRODUCTION

1.1 Purpose of document

Tiwest Pty Ltd (Tiwest) is planning a minerals sands mining and concentrating operation some 25km southeast of Dongara, Western Australia (Tiwest Dongara Project). A general description of the proposal and associated potential impacts was referred to the Environmental Protection Authority (EPA) by Tiwest during 2007 in accordance with Section 38 of the Environmental Protection Act 1986. In September 2007 the EPA set a level of assessment of Public Environmental Review (PER) with a four week public review period.

The Dongara Project was also referred to the Department of Environment, Water, Heritage and the Arts (DEWHA) in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) in August 2009. The DEWHA determined the project under Section 75 of the EPBC Act to be a controlled action based on the potential impacts of the project on Threatened Communities and Species protected by the EPBC Act. Following this decision, the DEWHA confirmed that the project will be assessed using the bilateral agreement between the Commonwealth and the Western Australian Government. The bilateral agreement will utilise the EPA's assessment process at the PER level.

This Environmental Scoping Document is the first stage of the Public Environmental Review Assessment process and has been prepared in accordance with the Guide to Preparing an Environmental Scoping Document (EPA 2007) to comply with requirements of the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002.

The Environmental Scoping Document:

- describes the main components of the proposal
- identifies relevant environmental factors, potential environmental impacts and their significance
- specifies the studies to be undertaken to define the potential environmental impacts
- proposes management options to minimise the environmental impacts identified

1.2 Proponent details

Proponent: Tiwest Pty Ltd, operator of the Tiwest Joint Venture; an equal share joint venture between Tronox Western Australia Pty Ltd and Exxaro Minerals Sands Pty Ltd (as Yalgoo Minerals Pty Ltd)

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1.2.1 The Tiwest Joint Venture

The Tiwest Joint Venture is one of the world's most successful titanium minerals production and processing companies. Operating at six sites in Western Australia, Tiwest has established a major titanium minerals operation by mining heavy mineral sands, separating titanium minerals and zircon; producing synthetic rutile and manufacturing titanium dioxide pigment in one integrated business. The integrated operations have made an important contribution to Western Australian export earnings, as well as directly generating more than 800 full time and contract jobs.

Tiwest's success has been built on the development of high quality mineral reserves and the application of sophisticated downstream process technology. After more than eighteen years in production, the company has established one of the most efficient operations in the industry. Key elements in the company's achievements have been priority programs for safety, environmental performance and community responsibility.

The integrated nature of the operations is shown in schematic by Figure 1.2.1.

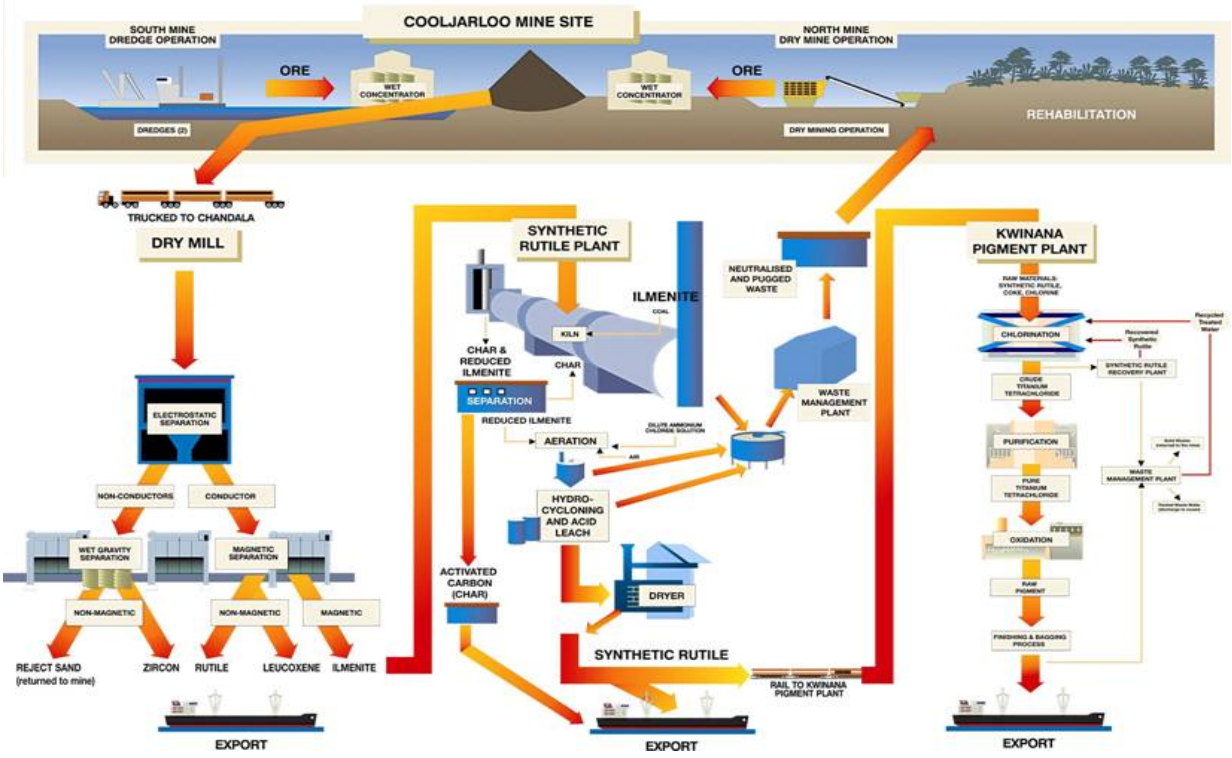

Figure 1.2.1 Schematic of Tiwest's operations

1.2.2 Ownership

Tiwest Pty Ltd is the operations manager of the Tiwest Joint Venture, a joint venture of equal interest between subsidiaries of Exxaro Sands Australia Pty Ltd (as Yalgoo Minerals Pty Ltd) and Tronox Western Australia Pty Ltd.

Exxaro Sands Australia is a solely owned subsidiary of South African based Exxaro Resources Limited who have iron ore, coal, base metals and minerals sands interests.

Tronox Western Australia is the Australian arm of American based chemical company Tronox, the world's third-largest producer and marketer of titanium dioxide pigment. Tronox also produce electrolytic and specialty chemicals.

1.2.3 Tiwest's Operations

Tiwest's operating production, product storage and administration sites (refer to Figure 1.2.2) are:

- Cooljarloo, 170 kilometres north of Perth, where the company produces heavy mineral concentrates from dredging and dry mining operations.
- Chandala, 60 kilometres north of Perth, where the valuable minerals ilmenite, rutile, leucoxene and zircon are split from the heavy mineral concentrate. The ilmenite is also refined to synthetic rutile at Chandala producing activated carbon as a by-product.
- Kwinana, 30 kilometres south of Perth, where synthetic rutile is processed to titanium dioxide pigment then stored or shipped to overseas markets.
- Bentley, the company's corporate administration office near the centre of Perth.
- Henderson product storage facilities.
- Bunbury Port export facility.

Mineral products are stored and transported from Bunbury Port and Henderson storage facilities.

1.2.4 Environmental Management System

Tiwest Pty Ltd (Tiwest) have operated in accordance with International Standard AS/NZS ISO 14001:2004 since 1994, subsequent to the development of an Environmental Management System (EMS) for its Western Australian Operations. The purpose of the EMS is to manage the impact of Tiwest's operations on the environment and ensure that these operations are conducted in accordance with existing legislative requirements. The Dongara project area will be included in the existing Tiwest Safety Health and Environmental Management System.

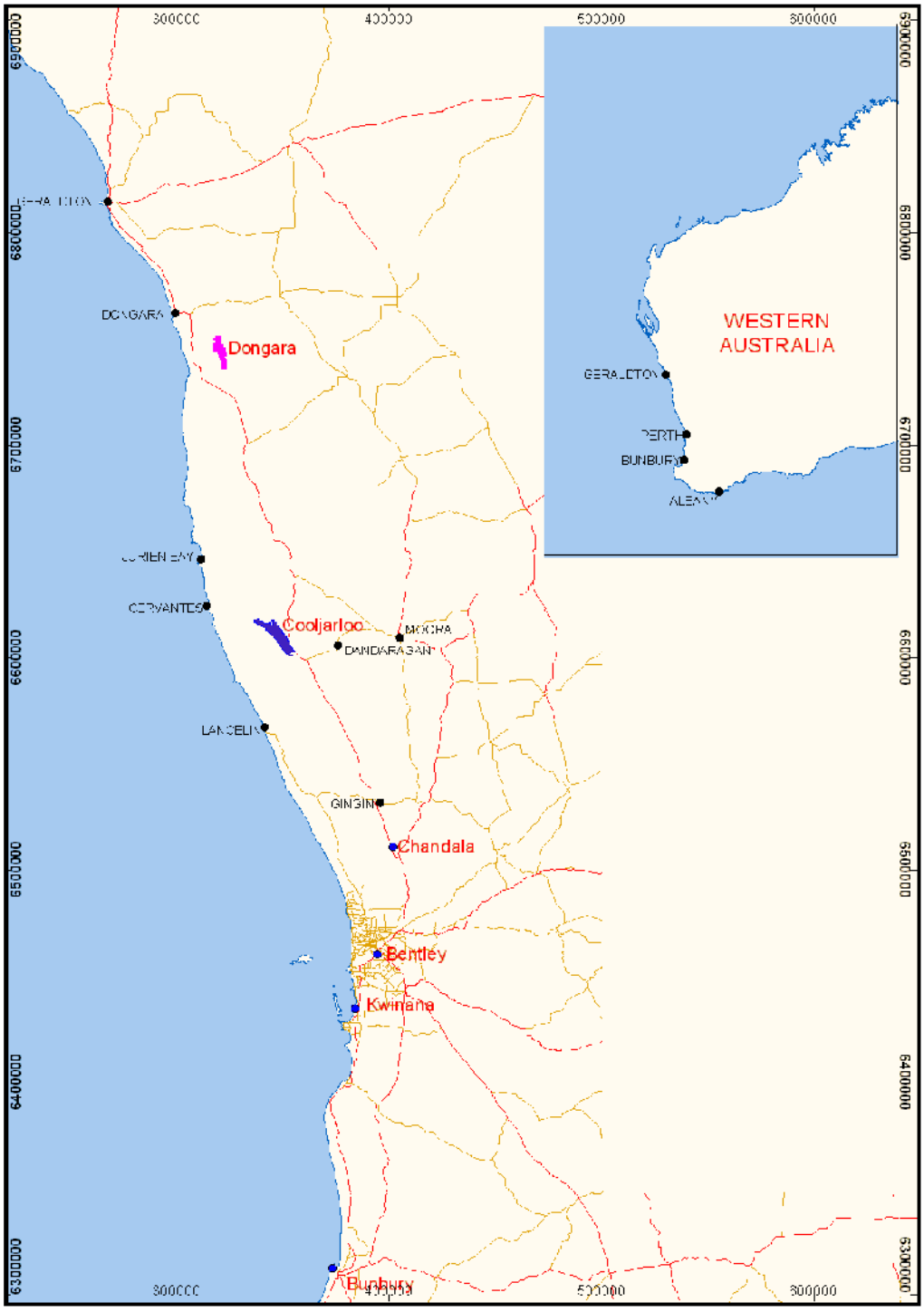

Figure 1.2.2 Location of Tiwest Operations

2. DESCRIPTION OF THE PROPOSAL

The Tiwest Dongara Project proposes to mine and concentrate titanium bearing (and other valuable) mineral sands from resources identified some 25km southeast of the Dongara township (refer to Figure 1.2.1). The resultant concentrate will be transported to the Tiwest Chandala Dry Mill (Muchea) for processing and separation

into its various mineral components prior to sale or, in the case of ilmenite, further processing into synthetic rutile and ultimately, titanium dioxide pigment at the Tiwest Kwinana Pigment Plant.

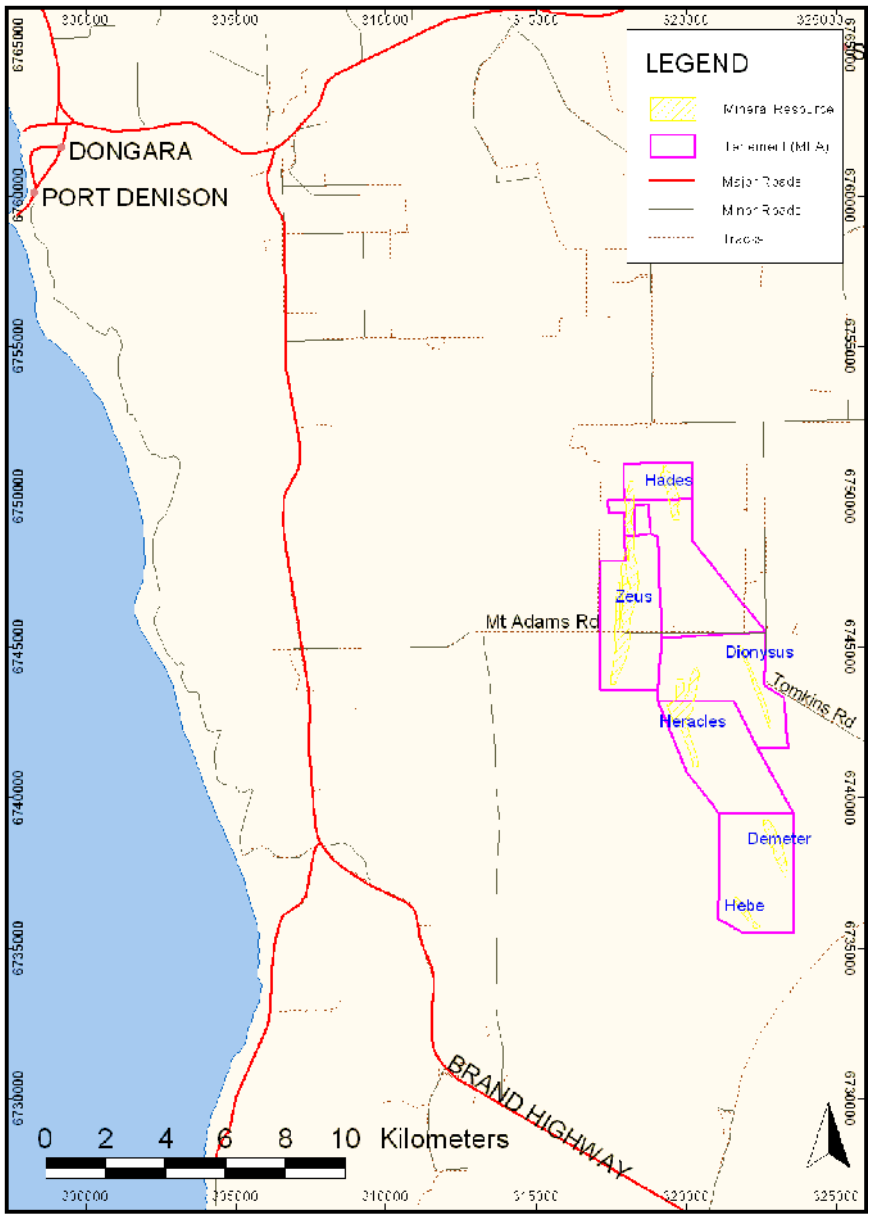

Figure 1.2.1 Dongara Project Location

At this time, the mine plan is conceptual only. Collection and assessment of information critical to the development of a detailed project plan, including baseline environmental surveys and impact assessment, is presently in progress. The detail of the proposal will evolve through the planning process.

Additional exploration is also underway within both the listed Mining Leases and surrounding Exploration Leases and is planned to continue throughout the assessment of this PER. Assessment and approvals required for such exploration will be sought separately in

accordance with the appropriate requirements. Any additional resources identified for inclusion in the project will be referred for assessment separately.

2.1 Key Project Parameters

Key project parameters are provided in Table 1. Standard truck and shovel methods will be used to remove overburden. One of two options will be utilised for ore removal. Either a mobile screening and pumping plant, for example SlurryTrak, will be used to slurry and pump ore from the pit, eliminating the need for mobile hauling equipment. The SlurryTrak will be located adjacent to the mining face where oversize can be left on the pit floor and will require little if any rehandling. Alternatively, standard mobile mining equipment will be used (truck and shovel). In this option the ore will be fed directly to the feed preparation unit. Oversize will be returned to the mine void.

With either method, ore is then further processed in a Feed Preparation unit and then pumped to a Wet Separation Plant. The wet separation will be via gravity spirals and will not involve any chemical processing. The resultant heavy mineral concentrate will be transported to the Tiwest Chandala Dry Mill for further processing.

Sand and clay materials that are separated from the concentrate, known as tailings, will be returned to the mine voids shown in Figure 2.3.1 for incorporation in the rehabilitated landform. The rehabilitated landform will be constructed in a manner that facilitates the achievement of rehabilitation objectives of a safe stable landform commensurate with pre-disturbance landform, hydrological and ecological characteristics. Mining, separation and subsequent deposition of sand and slimes is anticipated to be free of any process chemicals and the tailings products are inert sand and clay. Slimes are typically flocculated with biodegradable synthetic flocculants/coagulants. Disposal of slimes and sand tailings will use a combination of solar drying and co-disposal.

Table 1: Tiwest Dongara Minerals Sands Project Key Project

Operational Life	~7 years
Land Management responsibility	Total of 5,192ha comprising M70/1195 – 273ha (Freehold Pasture) M70/1196 – 997 ha (uCL uncleared) M70/1197 – 958ha (uCL uncleared) M70/1198 – 999ha (uCL uncleared) M70/1199 – 990ha (uCL uncleared) M70/1200 – 975ha (uCL uncleared)
Mining Method	Dry mining
Mining Depth	Top of Ore 0 to 33mbgl (Average 10mbgl) Total Depth 10 to 45mbgl (Average 15mbgl)
Volumes Mined	Overburden~16,700kbcm Ore~14,600kbcm
Processing Technique	Wet gravity separation
Processing Rate	250-1100 tonne per hour
Estimated Production	~1,882 kt of heavy mineral concentrate
Area to be cleared	~900 ha (of which approximately 60ha is pasture the remainder native vegetation)
Water Demand	~2.5GL/yr
Water Supply Sources	Yarragadee abstraction bores Superficial abstraction bores and pit water (dewatering).
Bulk Fuel Storage	~100 kL of diesel
HMC transport truck movements (Cooljarloo and Dongara Combined)	Max of 40 return trips a day Average 27 return trips a day Both at a mean load of 80 t
Workforce (Operational)	50 to 70 employees & contractors (total)

mbgl = metres below ground level, GL/yr = gigalitres (1,000,000 litres) per year, L/s = litres per second, uCL = unallocated crown land, ha = hectares, t = tonnes, kbcm = 1,000 bank cubic metres

2.2 Timing and Staging of the Proposal

The timing of project commencement is dependant on progress of mining at the Cooljarloo Project and corresponding demand for feedstock supply at the Chandala and Kwinana Plants and general economic circumstances.

At this time it is likely that a shortfall in feedstock will require production at Dongara to commence in 2015. Site preparation works including installation of site infrastructure, roads, power plant etc will be required to commence some 12 months prior to this, ie in 2014.

The expected production timeframe is five to seven years. The project will involve three main stages:

1. 2013 to 2014 - Site Preparation Works – including but not limited to installation of critical infrastructure such as construction of access and internal roads, power reticulation, equipping abstraction borefield, construction of plant sites, tailings storage facilities and starter mine void, laying of pipelines, and installation of administration buildings/offices.

2. 2014 to 2021 - Commissioning and Operation – including but not limited to relocation, installation and commissioning of plant and equipment, and commencement of mining, mineral production, and progressive rehabilitation.

3. 2022 – 2025 Decommissioning – including but not limited to removal of remaining plant and infrastructure, final landform reconstruction and rehabilitation.

2.3 Mining Process

The mining and mineral concentration process involves:

- Clearing and mulching (or stockpiling) of native vegetation.
- Stripping and stockpiling of topsoil and subsoil for re-use in rehabilitation.
- Removal of overburden where necessary.
- Ore mining and delivery to the Feed Preparation unit.
- Feed preparation including screening to remove oversize (+150 mm), secondary screening to reject the +3 mm to -150 mm fraction and then scrubbing to break up any remaining clay lumps.
- Slurried ore is then pumped to a wet gravity concentration plant where it passes through a series of gravity spirals to produce a Heavy Mineral Concentrate (HMC).
- Tailings and overburden disposal into mined pits to enable landform reconstruction or external structures as necessary.
- Replacement of topsoil.
- Rehabilitation of disturbed areas.

There are two sections to the Dry Mine processing plant:

- Feed Preparation Unit
- Wet Concentrator facility

A conceptual layout for the site is provided as Figure 2.3.1 which shows ore reserve names and location of major infrastructure. A breakdown of the area required for all roads and infrastructure components will be included in the PER.

The feed preparation unit is semi-mobile and is relocated on average every six months. The Wet Concentrator may be relocated up to three times during the life of the project (depending on the final project plan) but will most probably remain in one location.

Water required for processing and other requirements will be supplied from production bores and mine dewatering, and stored in mine voids or process water dams.

The western deposits of Zeus, Heracles and Hebe will be mined to below the water table at the deepest points. Preliminary modelling of pit inflows by Parsons Brinckerhoff Pty Ltd has shown that groundwater inflows to in-pit sumps may provide most or all of the requirements for the concentrator water supply during these times, accounting for approximately 2 years of mining in total. However the superficial aquifer is not considered suitable for bore water supplies for the mining operation because of relatively low bore yields, and because the areas with sufficient saturated thickness are near to areas of shallow water table depth where groundwater-dependent vegetation could potentially be impacted by drawdown.

Tiwest proposes to install four Yarragadee production bores to provide the water supply for the mining operations. The bores will be situated close to a main mine access road extending between the Hades and Dionysus deposits and will be spaced about 2.5 km apart (Figure 2.3.1). Each bore will have a nominal design flow capacity when running of 40 L/sec, however, actual yield will not be known until they are installed. Figure 2.3.1 also shows a pair of observation bores, DOB01 and DOB02, and a production bore, DPB01, installed in the superficial formations in 2008. The locations of these bores are more clearly shown in Figure 6.4.1.

The return of clay and sand tailings to the mine void during operation at the Dongara project may be conducted using one of two methods, or a combination of both. The method used will depend on the characteristics of the clay fines. The first method, called “co-disposal”, combines the sand and clay tails before returning it directly to the mining void. The second method returns the clay and sand tailings separately to the mining void as the clay is first consolidated by evaporating any excess water from the material in solar drying cells. Tiwest uses the second method successfully at Cooljarloo and is currently evaluating the first method, co-disposal, for future operations. Other mineral sands companies have successfully utilised co-disposal in their operations.

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Legend

- Minor Roads
- Groundwater bores
- Infrastructure
- Reserve
- Resource
- Solar Drying Dams
- Overburden Dumps
- Outline
- Tenement (MLA)
- DBNGP Proposed Future Expansion
- Hudson Resources

Hades

Zeus

Mt Adams Road

Beharra Springs Facility Access Road

Heracles

Dionysus

Existing Beharra Springs Compressor Station

Beharra Springs North Access Road

Demeter

Hebe

0 0.5 1 2 Kilometers

Tiwest Dongara Project area

Date: 6th January 2010

File Ref: AVPDONO31

Scale: 1:50,000

Figure 2.3.1: Conceptual Site Layout

2.4 Radiological content of mineral ore

The approximate composition of Heavy Mineral Concentrates (HMC) that will be produced as a result of the mining process are presented in Table 1. Of the minerals within the HMC, Ilmenite, Zircon and Rutile will be separated out during processing for further refinement.

Heavy mineral sands often contain naturally occurring radioactive elements. These are principally uranium and thorium and their associated decay series. Of the minerals contained within the Dongara Project HMC, the highest content of these radionuclides is in Monazite. Monazite constitutes on average 1.02% by weight of the Heavy Mineral Concentrate (HMC) in the Dongara ore bodies (Table 2). Monazite is not separated out in the laboratory analysis since Tiwest don't produce it as a product, it is considered a waste. A Minerals Liberation Analysis (MLA) Report completed by JKTech for the Dongara project listed the Uranium and Thorium levels in Monazite as 1% and 5.1% respectively (Table 3). These levels are the average of all minerals within the Monazite group providing an indication of the potential Uranium and Thorium levels in the Monazite contained within the Dongara HMC.

Other heavy minerals in the ore also contain thorium and uranium but at concentrations, in general, several of orders of magnitude less. The Uranium and Thorium content of Ilmentite and Rutile within the Dongara HMC are shown in Table 4. The ore bodies presented in the table, Dionysus, Heracles and Zeus, represent the greatest percentage of the Dongara HMC.

Results are not available for Zircon as the laboratory scale processing only produces a small amount of this product and it was not assayed for Uranium and Thorium. Zircon is not considered to contribute to radiation levels due to the small quantity produced.

Information on the radiation levels in overburden and tailings material will be included in the PER. Radiation is listed as a relevant environmental factor in Section 5 and the potential impacts are described in Error! Reference source not found.. The key risks, studies and proposed management associated with radiation are covered in Section 6.9.

Table 2: Composition of Heavy Mineral Concentrate in the Dongara Deposits

Mineral	Zeus South	Zeus Middle	Zeus North	Heracles South	Heracles North	Dionysus South	Dionysus Central	Dionysus North	Hades	Demeter	Hebe	AVG
Ilmenite %	48.8	47.2	41.7	48.2	54.5	46.7	49.4	44.7	50.0	47.2	52.7	48.3
Rutile %	7.89	7.86	5.5	7.38	7.88	7.37	7.85	6.23	8.49	7.6	9.69	7.61
Zircon %	14.8	18.1	11.5	7.56	9.8	7.09	4.98	7.35	10.6	6.69	20.8	10.8
Monazite %	2.05	2.88	1	0.59	1.31	0.44	0.24	0.47	0.67	0.42	1.15	1.02
Other %	26.8	24.2	40.6	36.4	26.6	38.5	37.6	41.4	30.5	38.2	15.7	32.4
Trash	26.3	25.2	39.6	35.3	26.1	37.4	36.3	39.9	30.4	37.2	15.4	31.7

Table 3: Uranium and Thorium content of Monazite

Group	Th (%)	U (%)
Monazite	5.1	1.0

Table 4: Uranium and Thorium content of Ilmenite and Rutile for Dionysus, Heracles and Zeus.

	U+Th (ppm)	U+Th (ppm)
Mineral	Ilmenite	Rutile
Dionysus	90	140
Heracles	110	180
Zeus	120	90

2.5 Basis for justifying the proposal and selecting the preferred option

Tiwest is the world's largest integrated titanium minerals production and manufacturing company. Operating at six sites in Western Australia, the company has established one of the most efficient operations in the industry, as well as generating more than 800 full time and contract jobs. Tiwest contributes over A$50 million in annual payroll, and regular incomes for an estimated 500 businesses with spending of A$250 million on goods and services annually.

Tiwest mines titanium minerals at its Cooljarloo Operations from two sites; one a dredging operation and the second a conventional dry mining operation, to produce over three quarters of a million tonnes of the Heavy Mineral Concentrate (HMC) per annum. The dredge mine was commissioned in 1989 and has been in continuous operation since, with an expected 15 year plus remaining life left. The dry mine commenced in 1997 and will complete mining at Cooljarloo between 2011 and 2015 dependent upon the economics of mining the near surface resources available to it.

Typically the dredge mine provides two thirds of the required HMC for further processing at Chandala Operations, with the dry mine providing the other one third. If no activities are undertaken to replace this supply of HMC, then downstream mineral supplies and pigment production will be affected, reducing sales, government royalties, company profitability and inevitability jobs and the security of other supporting businesses.

Tiwest has considered a number of alternatives to manage the anticipated shortfall. The first consideration is an expansion of the current dredging operations to make up the shortfall in HMC. This option shortens mine life at Cooljarloo and is capitally intensive. The second is to secure mineral supplies through purchasing arrangements with other processing companies. However, such supplies of external minerals are all ear-marked for existing customers and are not generally available in the needed quantities. Discussions with other West Australian producers to mine deposits under various arrangements have not reached a successful conclusion to date. The final alternative considered is to acquire a new source of minerals suitable for treatment using the existing dry mine infrastructure and to relocate the equipment and people to maintain the supply of HMC. This last option was pursued by the Joint Venturers, though all options are reviewed annually.

In 2003, the Dongara Project and related exploration tenements were acquired through the purchase of Magnetic Minerals Limited by Tiwest JV partner, Ticor Ltd. This was subsequently merged into the assets managed by the integrated Joint Venture in 2006. Tiwest has embarked on various environmental, engineering and feasibility studies to ascertain the risks and value of the Project and continues to actively pursue exploration objectives west of Cooljarloo.

It is envisaged that the Dongara Project will maintain current downstream operating capacities for the Tiwest JV and secure the current levels of productivity for all stakeholders.

3. APPLICABLE LEGISLATION AND GUIDELINES

3.1 State Legislation

Key State legislation relevant to the Dongara Project includes:

- Aboriginal Heritage Act 1972
- Agriculture and Related Resources Protection Act 1976
- Bush Fires Act 1954
- Conservation and Land Management Act 1984
- Contaminated Sites Act 2003
- Dangerous Goods Safety Act 2004
- Environmental Protection Act 1986
- Environmental Protection (Noise) Regulations 1997
- Land Administration Act 1997
- Local Government Act 1960
- Mines and Safety Inspection Act 1994
- Mineral Sands Mining and Processing State Agreement Act 1988
- Mining Act 1978
- Occupational Health and Safety Act 1984
- Radiation Safety Act 1975
- Rights in Water and Irrigation Act 1914
- Wildlife Conservation Act 1950

3.2 Commonwealth Legislation

Under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), approval is required from the Federal Environmental Minister if an action has, will have, or is likely to have a significant impact on a matter of national significance. The seven matters of national significance recognised by the EPBC Act are:

1. World heritage sites
2. National Heritage Places
3. Wetlands of international importance (RAMSAR wetlands)
4. Listed threatened species and ecological communities
5. Listed migratory species
6. Nuclear actions
7. Commonwealth marine environment

Of these matters, the Dongara project has potential to impact on 4 and 5. As such, Tiwest will refer the project for assessment concurrent with the submission of this Scoping document.

3.3 Guidelines and Standards

The State and Commonwealth policies, EPA position statements, EPA guidance statements and relevant environmental guidelines and Codes of Practice potentially applicable to the Proposal include:

EPA Position Statements:

- No. 2: Environmental Protection of Native Vegetation, December 2000
- No. 3: Terrestrial Biological Surveys, March 2002
- No. 4: Environmental Protection of Wetlands, EPA 2004
- No. 7: Principles of Environmental Protection, EPA 2004
- No. 9: Environmental Offsets, EPA 2006

EPA Guidance Statements:

- No. 6: Rehabilitation of Terrestrial Ecosystems, EPA 2006
- No. 8: Environmental Noise (DRAFT)
- No. 12: Minimising Greenhouse Gas Emissions, EPA 2002
- No. 19: Environmental Offsets
- No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia
- No. 33: Environmental Guidance for Planning and Development, EPA 2008
- No. 41: Assessment of Aboriginal Heritage, EPA 2004
- No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, EPA 2004
- No. 54: Sampling of Subterranean Fauna in Groundwater and Caves, EPA 2003
- No. 54a: Sampling methods and survey consideration for subterranean fauna in Western Australia (DRAFT)
- No. 55: Implementing Best Practice, EPA 2003
- No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, EPA 2004

Environmental Guidelines and Strategies:

- Department of Water (DoW): Water Protection Guidelines for Mining and Mineral Processing (DoW 2000-2005)
- Department of Mines and Petroleum: Guidelines for the Safe Design and Operating Standards for Tailings Storage (DME 1999)
- Department of Environment and Conservation (DEC): Guidelines for Compliance Monitoring (DEC 2005a)
- DEC: Guidelines for Preparing Environmental Management Plans (DEC 2005b)
- DEC Acid sulphate soils guidelines:
    - Identification and Investigation of Acid Sulphate Soils Guideline (DEC 2009)
    - Draft Treatment and management of soils in acid sulfate soils landscapes (DEC 2009)
- Draft Biodiversity Conservation Strategy for Western Australia
- Western Australian State Sustainability Strategy
- Western Australian Greenhouse Strategy

4. ENVIRONMENTAL AND SOCIAL SETTING

4.1 Existing Land Use and Tenure

Land tenure and use within the project area is shown in Figure 4.1.1. The project area is defined by mining tenements M70/1195, M70/1196, M70/1197, M70/1198, M70/1199 and M70/1200 (M70/1195-1200) as shown in Figure 4.1.1. These tenements are wholly contained with Exploration Licences E70/1592, E70/2263 and E70/2347. Tiwest also holds the adjoining tenement E70/2430 to the south.

Tenements M70/1196-1200 are in unallocated Crown Land. Part of the area overlays the active gas mining facility Beharra Springs a joint venture of ArcEnergy Pty Ltd and Origin Energy Pty Ltd (operator). A private agreement is in place to facilitate mining of mineral sands concurrently with the operation of Beharra Spring gas facility. The Dampier, Perth to Bunbury Natural Gas Pipeline (DPBNG) and Parmelia Natural Gas/Petroleum Pipeline also traverses the project area and are preserved via similar agreements.

M70/1195 is exclusively on freehold pasture, used predominantly for cattle grazing. The freehold land is subject to a land access and compensation agreement in accordance with Section 29 of the Mining Act 1978 in relation to access to surface rights for the purpose of minerals exploration. Independent negotiations are in progress with the relevant landholder to secure access to this area for mining purposes.

Areas of the unallocated crown land are also used for the purpose of wildflower and native seed harvesting, by apiarists and by people of the Amangu Aboriginal Group.

Mining Lease M70/1196 also wholly surrounds Mining Lease M70/361, held by Hudson Resources Pty Ltd, for the undeveloped Dongara South Diatomaceous Earth deposit (Figure 4.1.1).

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Yardanogo Nature Reserve (36203)

Beekeepers Nature Reserve (24496)

M 70/1195
Hades
C. Forsyth
Murion Cattle Company
Zeus
M 70/1196
M 70/1197
Mt Adams Road
M 70/1198
Dionysus
UCL
Heracles
Beharra Springs Facility Access Road
M 70/1201
M 70/1199
M 70/1218
Tomkins Rd
Existing Beharra Springs Compressor Station
UCL
Beharra Springs North Access Road
Demeter
M 70/1203
M 70/1219
M 70/1200
M 70/1214
Hebe
M 70/1204
M 70/1207
M 70/1215
M 70/1210
M 70/1213
Summers
MLA70/1205
M 70/1205
M 70/1208
M 70/1216
Beharra Springs
DIA Site 5217
M 70/1209
M 70/1211
M 70/1212
BRAND HIGHWAY

0 0.5 1 2 Kilometers

Legend

- Mining Lease Applications
- Tiwest Live Mining Leases
- Dongara Resource
- Hudson Resources
- DIA Heritage Site
- Nature Reserve
- Major Roads
- Minor Roads
- Pipeline Corridor Buffer
- DBNGP Pipeline

Tiwest Dongara Project area

Date: 2nd February 2010

File Ref: AVPDONO33

Scale: 1:65,000

Figure 4.1: Land Tenure

4.2 Reserves

Yardanogo Nature Reserve (R11947), a C Class nature reserve is immediately west of the project area as shown on Figure 4.1.1.

The mining tenements partially intersect Water Reserve R10877. The justification for this reserve is a little unclear, however, most probably relates to springs, soaks or watering points for stock. These are not considered to be of great significance in terms of the groundwater resources for the region (pers. comm. Phil Commander Department of Water). This would be reinforced by the presence of Stock Route Reserve R10876 that intersects both the mining leases and the water reserve.

Mt Adams Road bisects the mining tenements running east west and the Zeus orebody. Reserves associated with the Dampier to Bunbury and Parmelia Natural Gas Pipelines run through the centre of the tenements.

4.3 Other Areas of Significance

Areas of environmental significance within and around the project include:

- Environmentally Sensitive Areas (ESA) exclusively associated with declared rare flora species e.g. Paracaleana dixonii (not within project footprint but nearby);
- Heritage Sites – refer to Section 4.12.

There are no Threatened Ecological Communities (TEC) or Groundwater Dependant Ecosystems (GDE) near or within the project area.

4.4 Existing and Proposed Land Uses in the Region

There are a variety of land uses and types of industry other than mining in the region surrounding the Dongara Project Area. Expansions of existing industry and the establishment of new industries has been occurring and may continue due to the construction of Oakajee Port at Geraldton and other drivers. Giving consideration to similarity of vegetation associations and habitats, of note to this assessment are Iluka Pty Ltd South Eneabba Expansion (pending ERMP), Aviva Corporation Ltd Central West Coal Project and Coolimba Power Station (current PER out for comment) and Tiwest Pty Ltd Falcon Expansion (approved in 2009 as per EPA Report 1299 and Ministerial Statement 790).

4.5 Climate

The project area experiences a Mediterranean climate with hot dry summers and mild winters. The nearest Bureau of Meteorology stations are Carnamah (008025) and Eneabba (008225). Average, maxima and minima data from these stations is presented in Figure 4.5.1 and Figure 4.5.2. Average annual rainfall at these sites is 504mm for Eneabba and

384mm at Carnamah with the majority falling during May to August. It is estimated that average annual rainfall received by the project area would be between the two sites, and as the project site is located nearer Eneabba, it may be closer to 504mm.

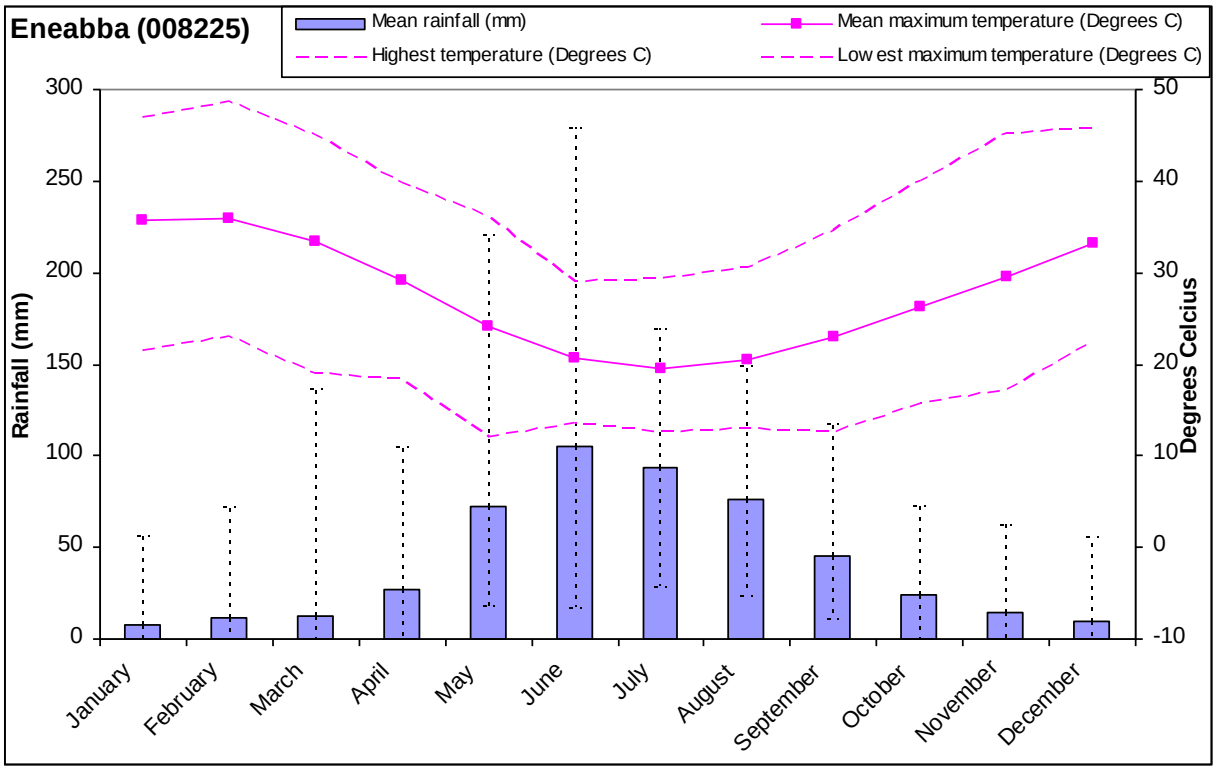


Figure 4.5.1: Meteorological averages for Eneabba Station 008225 (Bureau of Meteorology)

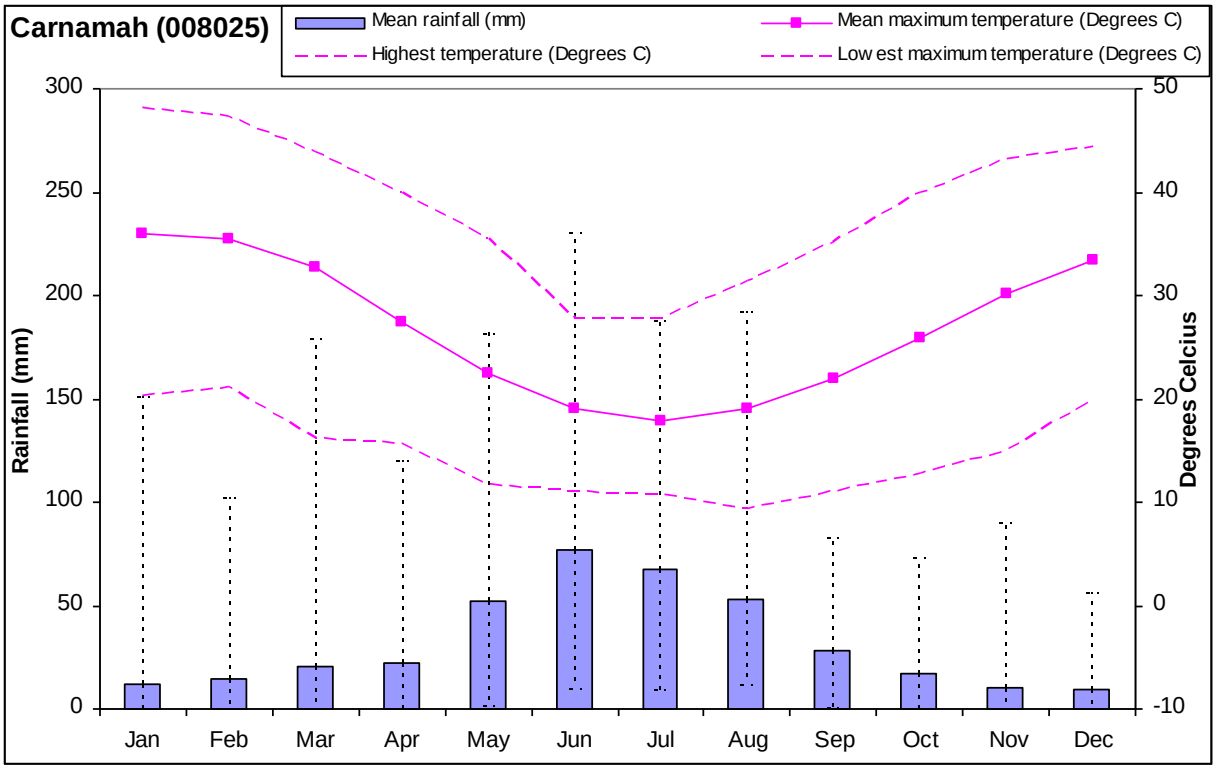


Figure 4.5.2: Meteorological averages for Carnamah Station 008025 (Bureau of Meteorology)

4.6 Flora and Vegetation

The following flora and vegetation descriptions are summaries from Woodman 2007. The project area is located within the Irwin Botanical District (Northern Sandplains Region), within the Southwest Botanical Province as defined by Beard (1990).

The western margin of the project area intersects the coastal limestone belt characteristic of the Illyarrie System. The Eridoon System comprises the majority of the project area and the Tathra System is on the eastern margin. These systems were further divided into vegetation community types (associations), related to physiognomy by Shepard et al (2002). There are 8 vegetation associations located within the Dongara project area (Table 5 and Figure 4.6.1).

4.6.1 Vegetation Mapping

In spring 2006/7 detailed structural mapping of vegetation communities was completed by Woodman Environmental over the region bounded by Exploration Licences E70/1592, E70/2263, E70/2347 and E70/2430 (which includes the relevant mining leases) shown in Appendix A. Listings of significant flora species (declared rare, priority and otherwise notable including range extensions and unknown/undescribed species) were also made. This returned 19 structural plant communities as illustrated in Appendix A and described below.

Forests

F1: Low Forest of Melaleuca rhaphiophylla over Open Dwarf Scrub on sandy clay in drainage lines.

Woodlands

W1: Woodland of Eucalyptus camaldulensis over mixed shrubs dominated by Acacia spp. and Melaleuca spp. on sandy clay soils in valleys and floodplains.

W2: Low Woodland of Melaleuca preissiana and Casuarina obesa on clay soils in basins and floodplains.

W3: Low Woodland of Eucalyptus erythrocorys over Thicket to Low Heath dominated by Acacia spp. or Melaleuca spp. on sand over limestone on mid to upper slopes.

W4: Low Woodland dominated by Banksia prionotes on yellow sand with occasional limestone outcropping on upper slopes and ridges.

W5: Open Low Woodland of Eucalyptus todtiana with occasional Xylomelum angustifolium and Banksia spp. over Open Shrubs to Heath dominated by myrtaceous and proteaceous species on grey sand on mid to upper slopes.

W5a: Open Low Woodland of Eucalyptus todtiana over Open Low Scrub dominated by Calothamnus quadrifidus on grey brown sand in creeklines.

W6: Open Low Woodland to Heath of Banksia attenuata and Banksia menziesii over mixed myrtaceous and proteaceous shrubs on grey and brown sand on mid to upper slopes.

W7: Open Low Woodland of Eucalyptus todtiana and Actinostrobus pyramidalis over Heath of mixed shrubs on grey brown sand on lower to mid slopes and swales.

Thickets

T1: Thicket dominated by Actinostrobus pyramidalis on clayey soils in basins and lower slopes.

T2: Thicket dominated by Allocasuarina campestris and Acacia spp. on sandy clay on lower slopes, gullies and basins.

T3: Thicket to Heath dominated by Banksia hookeriana and Banksia attenuata on yellow sand on mid to upper slopes.

T4: Dense Thicket of Melaleuca huegelii over Open Dwarf Scrub on sandy clay over limestone on lower slopes.

Heaths

H1: Heath dominated by Melaleuca systena in pans with impeded drainage

H2: Heath dominated by Banksia leptophylla, Calothamnus hirsutus and myrtaceous species in pans with impeded drainage

H3: Heath dominated by Hakea polyanthema, Beaufortia elegens, Calothamnus blepharospermus or Eremaea beaufortioides over Dwarf Scrub dominated by Ecdeiocolea monostachya on brown or yellow sand on lower to upper slopes.

H4: Heath dominated by Acacia spp. Calothamnus quadrifidus, Hakea lissocarpha and Melaleuca leuropoma with emergent Eucalyptus spp. on grey sand on lower slopes.

H5: Heath to Low Heath dominated by Dryandra spp. and Melaleuca aspalathoides on sand over laterite on lower to mid slopes.

The condition of the vegetation within the Dongara tenements was recorded as Pristine to Excellent. The majority of sites surveyed recorded minimal signs of disturbance. However, the project area has been impacted by 3D Seismic Surveys conducted by Origin Energy in 1998 and 2001. Longitudinal source and latitudinal receiver lines currently closed for rehabilitation purposes are visible throughout the project area.

There has been minor clearing for pipeline corridors and the Beharra Springs Gas Plant in the project area. In addition, areas near the eastern, western and northern boundaries of the project have been partially cleared and are adjacent to farming properties.

Table 5 Vegetation associations within the Dongara Project Area (from Shepard et al 2002)

Vegetation Association	Description	Current Extent (hectares)	Percentage of Pre-european Extent Remaining	Percentage held in IUCN Class Reserves	Reservation Priority*
352	Medium woodland; York Gum	113,255	15.2	3	L
377	Mosaic: Shrublands; scrub heath on limestone/ Sparse low woodland; illyarrie Shrublands; scrub heath with scattered Banksia spp.,	72,491	99.4	74	L
378	Eucalyptus todtiana and Xylomelum angustifolium on deep sandy flats	68,049	62.0	21.1	M
379	Shrublands; scrub heath on the lateritic sandplains	128,007	20.2	20.3	M
392	Shrublands; Melaleuca thyoides thicket	1554	42.6	16.4	H
433	Mosaic: Shrublands; Acacia rostellifera and Melaleuca cardiophylla thicket/ Sparsewoodland; illyarrie low	15,234	40.9	11.7	M
619	Medium woodland; River Gum (Eucalyptus camaldulensis)	114,211	99.9	0.2	N/A
748	Shrublands; Melaleuca thyoides thicket with scattered rivergum	312	79.7	48.9	M

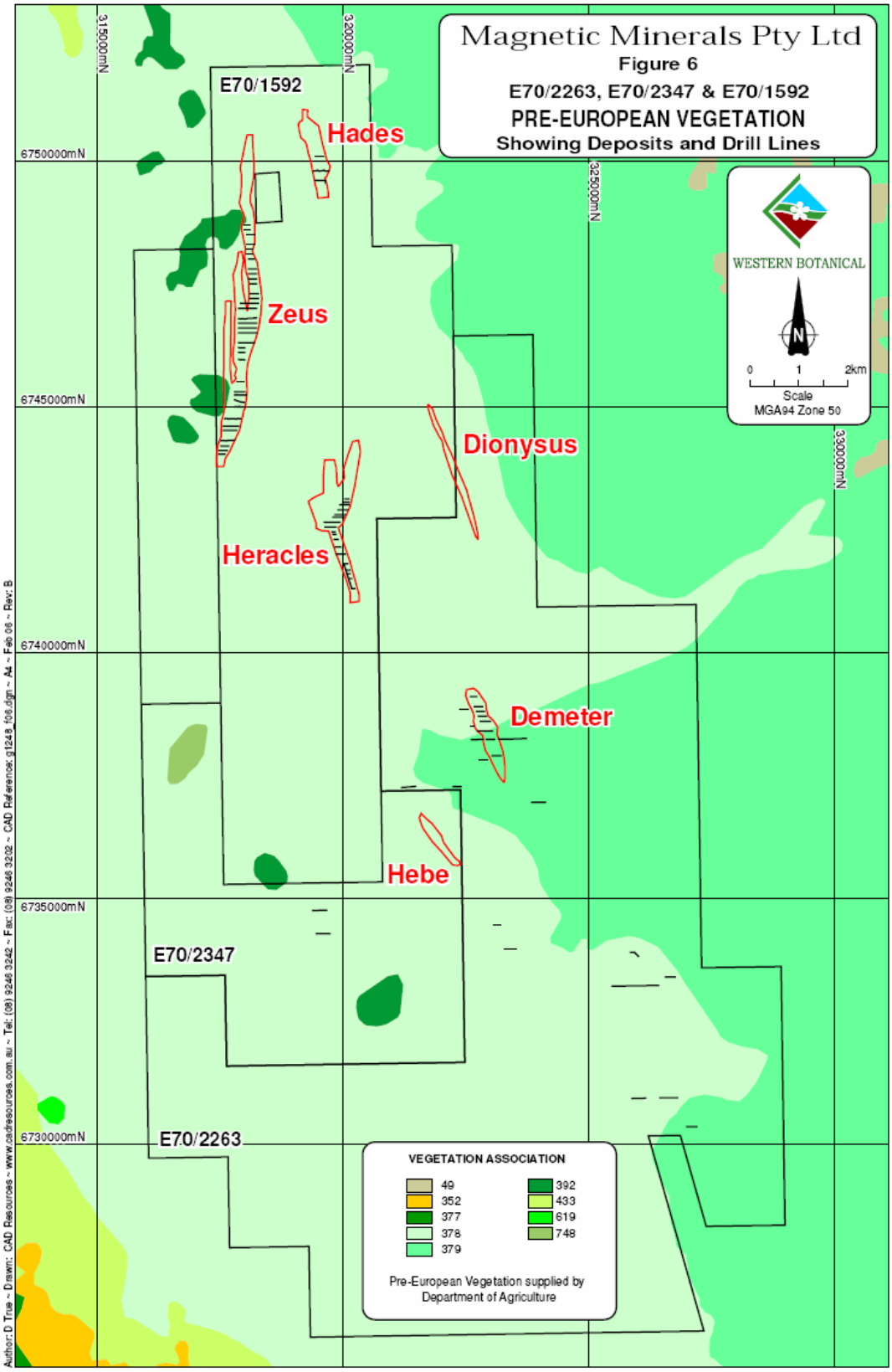


Figure 4.5.1: Pre European Vegetation Associations

4.6.2 Declared Rare and Priority Species

Rare and Priority Flora previously recorded within the project area or surrounding region are listed in Table 6Error! Reference source not found..

Table 6: Priority Flora Species Recorded in the Dongara Project Area during Surveys Conducted by Woodman Environmental Consulting in 2006 (WEC 2007a), 2007 and 2008 (Woodman 2009 in prep) in addition to data Provided by Western Botanical (2005a&b, 2006) and the Department of Environment and Conservation (2007a)

Species	Family	Comments
Acacia vittata (P2)	Mimosaceae	Dense rounded shrub to 4m with yellow flowers in Aug. Found on grey sands and clays on the margins of seasonal lakes
Baeckea sp. Walkaway (A.S George 11249) (P3)	Myrtaceae	A dense multi stemmed shrub to 2m. White flowers between Dec – Jan. Found on yellow, brown or white sand
Banksia elegans (P4)	Proteaceae	Fire tolerant shrub to 4m. Yellow green flowers between Oct – Nov. Found on yellow, white or red sands on sandplains and dunes
Banksia scabrella (P4)	Proteaceae	Many branched shrub to 2m. yellow, purple flowers between Sep – Jan. Found on white, grey or yellow sands on sandplains and lateritic ridges
Beyeria gardneri (P3)	Euphorbiaceae	Shrub to 0.5m with yellow flowers between Aug – Sep. Found on yellow sand
Calectasia palustris (P1)	Dasypogonaceae	Stilted herb to 0.7m with blue flowers between Jul – Oct. Found on white or grey sand and clay in damp areas.
Calytrix chrysantha (P4)	Myrtaceae	Shrub to 1.3m with yellow flowers between Dec – Feb. Found on white, grey or yellow sand flats.
Comesperma griffinii (P2)	Polygalaceae	herb to 0.2m with white flowers in Oct. Found on yellow or grey sand on plains
Eremaea acutifolia (P2)	Myrtaceae	Spreading shrub to 0.7m with orange and pink flowers between Aug – Nov. Found on grey or yellow sand
Eucalyptus macrocarpa subsp. elachantha (P4)	Myrtaceae	Spreading mallee to 4m. Red or pink flowers between Aug – Dec. Found on white and grey sands over laterite on sandplains, hills and ridges

Species	Family	Comments
Eucalyptus macrocarpa x pyriformis (P3)	Myrtaceae	Erect open mallee to 6m. Red flowers between Apr-Oct. Found on sand and lateritic soils.
Eucalyptus zopherophloia (P4)	Myrtaceae	Spreading mallee to 4m. Cream, white flowers between Oct – Jan. Found on grey or white sand with coastal limestone
Gastrolobium callistachys (P4)	Papilionaceae	Weeping shrub to 3m with yellow and orange flowers between Sep – Nov. Found on sandy soils and granite outcrops.
Georgeantha hexandra (P4)	Ecdeiocoleaceae	Rhizomatous herb to 0.8m. Found on deep sands and damp sites.
Goodenia trichophylla(P3)	Goodeniaceae	Herb to 0.3m with pink and blue flowers. Found on grey sand over laterite.
Grevillea erinacea (P3)	Proteaceae	Prickly, spindly shrub to 1.8m with green, white and cream flowers between Jul – Dec. Found on white, grey and yellow sands and laterite
Guichenotia alba (P3)	Sterculiaceae	Slender shrub to 0.5m. White flowers between Jul – Aug. Found on sandy, gravelly soils in low flats and depressions
Hemiandra sp. Eneabba (H. Demarz 3687) (P3) ^	Lamiaceae	Straggly shrub to 0.9m. Blue, violet flowers in February growing on sandy soils
Hopkinsia anoectocolea (P3)	Restionaceae	Rhizomatous, perennial to 1m. Brown flowers between Sep – Dec. Found on white or grey sands and in saline depressions.
Hypocalymma gardneri (P3)	Myrtaceae	Shrub to 0.3m with yellow flowers between Aug – Sep. Found on grey and brown sands and laterite
Lasiopetalum ogilvieanum (P1)	Sterculiaceae	Shrub to 1.5m Pink, white flowers between Jul – Oct. Found on white, grey or yellow sands and stoney soils.
Mesomelaena stygia subsp.deflexa (P3)	Cyperaceae	Tufted grass-like sedge to 0.5m. Brown, black flowers between Mar – Oct. Found on white or grey lateritic sands and gravelly clays
Persoonia filiformis (P2)	Proteaceae	Spreading shrub to 0.4m. Yellow flowers between Nov – Dec. Found on yellow or white sands over laterite
Persoonia rudis (P3)	Proteaceae	Erect or spreading shrub to 1m. Yellow flowers between Sep – Jan. Found on white, grey or yellow sands, sometimes over laterite

Species	Family	Comments
Schoenus griffinianus (P3)	Cyperaceae	Small tufted perennial to 1m., flowering between Sep – Oct. Found on white sands.
Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2)	Cyperaceae	clumped rhizomatous sedge to 0.8m. Found on grey, yellow or white sands
Stawellia dimorphantha (P4)	Anthericaceae	stilted herb to 0.2m with cream flowers between Jun – Nov. Found on white, grey or yellow sands.
Stylidium carnosum subsp. Narrow leaves (J.A. Wege 490) (P1)	Stylidiaceae	Cormaceous herb to 1m with white flowers between Oct - Nov.
Stylidium pseudocaespitosum (P2)	Stylidiaceae	Rosetted perennial to 0.2m with yellow flowers between Sep – Nov. Found on white, grey or yellow sands over laterite.
Verticordia luteola var. luteola (P3)	Myrtaceae	Slender shrub to 1.4m. White, yellow flowers between Nov – Dec. Found on grey sands over gravel

^includes specimen locations identified as Hemiandra ?sp. Eneabba (H. Demarz 3687)

From the EPBC Act database search there are 8 plant species listed in the project area.

Table 7: Listed threatened plant species identified as relevant from the EPBC Act database search of the project area.

Threatened Species	Status	Type of presence
Banksia serratuloides subsp. perissa Northern Serrate Dryandra	Vulnerable	Species or species habitat likely to occur within area
Hemigenia ramosissima	Critically Endangered	Species or species habitat may occur within area
Hypocalymma longifolium	Endangered	Species or species habitat likely to occur within area
Paracaleana dixonii Hopper & A.P.Br. nom. inval. Sandplain Duck Orchid	Endangered	Species or species habitat likely to occur within area
Schoenia filifolia subsp. subulifolia	Endangered	Species or species habitat may occur within area
Stawellia dimorphantha Arrowsmith Stilt-lily	Vulnerable	Yes, species occurs in the project area but is no longer considered rare or threatened.

A number of potentially undescribed species have been collected from the project area (Table 8).

Table 8: Undescribed or Poorly Known Taxa Recorded Within the Project Area (Woodman 2009 in prep)

Species	Comments	Potential Conservation Significance
Levenhookia sp.	located between Dongara and Wubin[1]	no
Calandrinia aff. liniflora	located between Dongara and Kalbarri[2]	no
Calandrinia aff. remota	located between Dongara and Kalbarri[2]	no
Stylidium aff. cygnorum	located between Jurien Bay and Dongara, abundant in the Coomalloo Nature Reserve[1]	no
Melaleuca aff. preissiana	located within Arrowsmith Lake and Yardanogo Nature Reserve	yes
Lepidosperma cf. tenue	Group currently being studied, definitive genetic work unlikely to be finished in 2009[3]	unlikely[3]
Lepidosperma sp. "Yuna Scabrid"	a number of populations known between Yuna and Wubin[3]	no

[1] pers. comm. Allen Lowrie
[2] pers. comm. Frank Obbens
[3] pers. comm. Russell Barrett

4.6.3 Flora and Vegetation Studies

Reviews, investigations and assessments of flora and vegetation completed and in draft form on a local and regional scale are tabulated in Table 9.

Table 9: Flora and Vegetation studies conducted in and adjacent to the Dongara Project Area

Study	Date	Completed by	Description
Dongara tenements Flora and Vegetation Studies Regional FCT Analysis	2009	Woodman Environmental Consulting	Unpublished report prepared for Tiwest
Eneabba Regional Vegetation Assessment	2008	Woodman Environmental Consulting	Report and maps prepared for Tiwest and Iluka Resources.
Dongara tenements: Flora, Vegetation and Phytophthora Cinnamomi Assessment	2007	Woodman Environmental Consulting	Unpublished report completed for Tiwest - flora, vegetation and Phytophthora Dieback studies of the Dongara tenements to support exploration and mine development.

Study	Date	Completed by	Description
Dongara infill and exploration drilling: application for ministerial permit to take (wildlife conservation Act 1950) Stawellia dimorphantha F. Muell. (anthericaceae) conservation status: R	2007	Western Botanical	Application for Tiwest. Surveys identified additional populations outside the reserve in adjacent uCL and therefore appear to support this.
Findings of taxonomic examination of the 680 Stylidium piliferum-complex gatherings housed in the Western Australian herbarium and from field work undertaken on the Tiwest tenements SE of Dongara	2007	Glenbar Enterprises	Microscopic examination of every specimen was undertaken to identify the key morphological characters of each species within the complex.
DRF and priority species survey on Dongara area tenements 25 exploration Lines	2006	Western Botanical	Unpublished report completed for Tiwest
Dieback assessment of Tiwest Joint Venture Dongara infill and exploration drilling	2006	Glevan Consulting	Unpublished report completed for Tiwest
DRF and priority species survey on proposed drill lines for the Dongara area tenements - Hebe ad Dionysus infill drilling	2005	Western Botanical	Unpublished report completed for Magnetic Minerals
Review and conservation significance of flora and vegetation of the Magnetic Minerals Dongara prospect October 2002	2002	Landcare Services Pty Ltd	Unpublished report for Magnetic Minerals

4.6.4 Dieback

No Phytophthora cinnamomi infestations were located during the assessment. However, a small part of the project area was determined to be unmappable for dieback interpretation due to the recent burn in adjacent vegetation. Coincidently, the unmappable areas were determined to be at the greatest risk of dieback infestation. These areas include the public, gravelled Mt Adams Road and the access road to the gas plant. The unmappable area will be resurveyed once sufficient regeneration has occurred prior to mining in the area or further exploration.

Potential impacts to flora are listed as a relevant environmental factor in Section 5 and in Table 11. The key risks, studies and proposed management associated with Regional and local Flora and Vegetation are covered in Section 6.1.

4.7 Geomorphology and Soils

The project area is within the major regional physiographic unit, termed the Swan Coastal Plain. Within this unit, three principal sub-units can be recognised in the general vicinity of the project. These, running west to east, comprise:

- the Quindalup Dune System, a coastal dune system of Holocene age (<10,000 ybp) (McArthur and Bettenay, 1960; Semeniuk et al., 1989) that has a width of 4.5km, followed by;
- the Spearwood Dune System, an inland dune system of Middle to Late Pleistocene age (800,000 ybp to 100,000 ybp), (McArthur and Bettenay, 1960), now referred to as the Tamala Limestone; and
- the Eneabba Plain (Playford et al. 1976), an area of undulating but gently rising plain between the Tamala Limestone and the Gingin Scarp.

The project area lies wholly within the Eneabba Plain (refer to Figure 4.7.1).

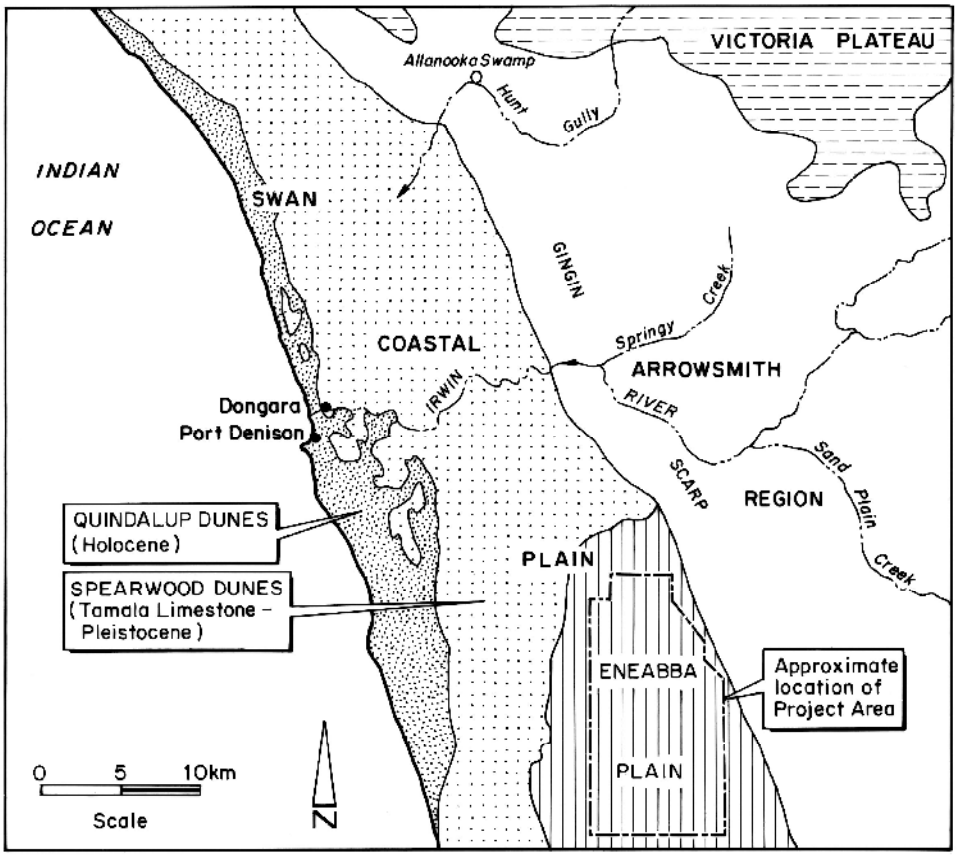


Figure 4.7.1 Regional time-stratigraphic framework showing the location of the project area within the boundaries of the Eneabba Plain (Blandford, 2007, as modified from Mory, 1995)

Two detailed field investigations have been completed to date by D.C. Blandford and Associates on behalf of Tiwest. The first (Blandford 2007) was undertaken in order to broadly characterise the landform and soil landscapes within the general project area and the second study focused on the soil profile characteristics of the paleo-lake system adjacent the western ore bodies.

Potential impacts of the project relating to soil quality and reconstruction of landforms and soil profiles during rehabilitation are listed as relevant environmental factors in Section 5 and described in Table 6. The key risks associated with Soil and Soil Landscapes are covered in Section 6.5.

4.8 Fauna

The Mt Adams study area lies within the Lesueur Sandplain subregion of the Geraldton Sandplains of the Interim Biogeographical Regionalisation for Australia (IBRA) classification system (EA 2000; McKenzie et al. 2003). The Geraldton Sandplains Bioregion falls within the Bioregion Group 1 classification of EPA (2004). The general features of this region are summarised by Desmond and Chant (2001).

The main fauna habitats present within the study area are:

- cleared farmland;
- mosaic of heath and low open woodland; and
- wetland and riparian habitats.

Tabulated below are the threatened fauna species that are listed for the Dongara Project area (Table 10). This information was extracted from a search of the EPBC Act database.

Table 10: Listed threatened fauna species identified as relevant from the EPBC Act database search

Threatened Species	Status	Type of presence
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo	Endangered	Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl	Vulnerable	Species or species habitat likely to occur within area.

Outlined below are the significant species that are expected to occur within the project area and those recorded during field surveys.

Amphibians

A total of 10 frog species are expected to occur in the study area (see Table 5 in Bamford 2007). No species were recorded during the site visit and none are considered to be of conservation significance. The seasonal wetlands

and watercourses present within the area may be used as breeding sites for a number of the frog species.

Reptiles

A total of 73 reptile species may occur in the Mt Adams Rd study area. Six of the reptile species that may occur in the study area are considered to be of conservation significance:

- Stokes' Skink - Egernia stokesii badia (CS1)
- Woma or Ramsay's Python - Aspidites ramsayi (CS1)
- South-western Carpet Python - Morelia spilota imbricate (CS1)
- White-spotted Ground Gecko - Diplodactylus alboguttatus (CS3)
- Diplodactylus ornatus (CS3) (Recorded in field surveys)
- Michaelsen's Gecko - Strophurus michaelseni (CS1)

Birds

A total of at least 136 bird species are expected in the Mt Adams Rd study area (Bamford 2007). Of these, conservation significant bird species include:

- Carnaby's Cockatoo - Calyptorhynchus latirostris (CS1) (recorded in field surveys)
- Major Mitchell's Cockatoo - Cacatua leadbeateri (CS1)
- Peregrine Falcon - Falco peregrinus (CS1)
- Fork-tailed Swift - Apus pacificus (CS1)
- Rainbow Bee-eater - Merops ornatus (CS1) (recorded in field surveys)
- Western Ground Parrot – Pezoporus wallincus flaviventris (CS1)
- Bush Stone-curlew - Burhinus grallarius (CS2)
- Rufous Fieldwren - Calamanthus campestris montanellus (CS2) (recorded in field surveys)
- White-browed Babbler - Pomatostomus superciliosus ashbyi (CS2)
- Crested Bellbird (southern) - Oreoica gutturalis gutturalis (CS2) (recorded in field surveys)
- Western Yellow Robin - Eopsaltria griseogularis (CS3)
- Southern Scrub-Robin - Drymodes brunneopygia (CS3)
- White-breasted Robin - Eopsaltria Georgiana (CS3) (recorded in field surveys)
- Eastern Great Egret - Ardea modesta (CS1)
- Square Tailed Kite - Lophioctinia isura (CS3) (recorded in field surveys)

Mammals

A total of 27 mammal species may occur in the study area, including 21 native and six introduced species. Two native mammals likely to be found in the study area are considered to be of conservation significance:

- Brush Wallaby - Macropus irma (CS2) (recorded in field surveys)
- Western Free-tail Bat- Mormopterus aff. planiceps (CS3)

Invertebrates

DEC's threatened and priority fauna database returned 3 species of conservation significance recorded in the Mt Adams area.

- Shield-backed Trapdoor Spider Idiosoma nigrum (CS1)
- Phasmid mimic cricket - Phasmodes jeeba (CS2)
- Millipede - Antichiropus 'Eneabba 1' (CS1)

Subterranean Fauna

EPA Guidance Statement No. 54 pertaining to subterranean fauna assessment states that the occurrence of significant subterranean fauna in the South-West region of Western Australia is likely to be associated with discrete geological features, particularly limestone formations. Any karstic systems in the South-West region are considered to have a high probability of containing a rich subterranean fauna.

No karstic systems are known or likely to be present within the project area. The nearest known cave formation are in the Arrowsmith area in excess of 10km to the south.

Little work has historically been undertaken in this area regarding stygofauna species present. However, considering the connected or continuous nature of the geology and associated aquifers it is unlikely that particularly geographically restricted species are present.

Potential impacts to threatened fauna are listed as relevant environmental factors in Section 5 and described in Table 6. The key risks, potential impacts and proposed management associated with Fauna are covered directly in Section 6.2 and indirectly within Sections 6.1, 6.3 and 6.4.

4.9 Hydrology

Watercourses

The site is bounded to the east by the Gingin Scarp, which reaches its maximum elevation of 256m at Mt Adams. The Gingin Scarp is characterised by a westerly facing slope and is the source area of two small relict ephemeral drainage systems that flow onto the site (Mt Adams Creek and Tompkins Rd Creek) shown in Figure 4.11.1 and Figure 4.11.2. These drainage systems are poorly defined and endoreic, in so much as they are internally draining and do not exit the site or discharge to the ocean, recharging the superficial aquifer locally via infiltration.

Stream flow is infrequent and episodic, a reflection of the localised catchment, sandy soils and influence of infrequent cyclonic (summer) rainfall. The Mt Adams Creek has been gauged since July 2007; however, no stream flow has yet been recorded.

The drainage system present today is believed to be a relict of a larger palaeo-drainage system that operated during much wetter periods, probably during the late Pleistocene (Blandford, 2008).

Soil bores and test pits have been used to identify diatomaceous earths, clays and siliceous pans lying at shallow depth on the western margin of the site (immediately to the east of the dominant Tamala Limestone ridge). These sediments are interpreted as being remnants of a much larger fluvio-lacustrine system that was contiguous along the length of the project area aligned north-south parallel to, but west of, the Zeus mineralisation. The feature extends for at least 25km or approximately the full length of the site. There is field evidence indicating that at least some ancient streams originating from the outwash fans fed this palaeo lake system (Blandford, 2008), however, this does not appear to be currently the case.

Potential impacts to Water is listed as a relevant environmental factor in Section 5 and described in Table 6. The key risks associated with Hydrology and Hydrogeology are covered in Sections 6.3 and 6.4 respectively.

4.10 Wetlands

A large portion of the relict palaeo-lake has been blanketed by the Eneabba Plain sand sheet and what remains exposed at the surface is all that remains of the past, well developed, extensive fluvio-lacustrine system (Blandford, 2007). Where the relict palaeo-lake remains exposed it appears as a modern day dampland of irregular morphology (referred to as the Zeus Wetland). Field surveys verify that this dampland is not generally subject to prolonged inundated or waterlogging, although the periodicity of inundation tends to increase to the north of the project area.

In its present-day form, siliceous pans and clay lenses associated with the relict palaeo-lake system serve to retard the vertical movement of meteoric rainfall, resulting in groundwater perching and/or elevated soil moisture in the overlying sediments. The extent of this retardation appears to be spatially discontinuous due to the high variability of the soil profiles surveyed, some with an impeding subsurface layer some without.

The Zeus Wetland has been previously assigned to the Beharra Spring consanguineous wetland suite and described as an intermittent dampland containing horizons of fossil wetland soils (Semeniuk, 1994). In accordance with the geomorphic wetlands classification system (DEC 2007), damplands are defined as seasonally waterlogged basins.

During peak groundwater conditions (September - October), the northernmost extent of the dampland system contains surface water (~0.5m depth) for approximately 2-4 months in most years. Generally, burial of the relict palaeo-lake system beneath the Eneabba Plain sand sheet increases (and the periodicity of inundation decreases) to the south of Mt Adams Road.

Where burial of the relict palaeo-lake system beneath the aeolian sand sheet is substantial (>4m), the transition from dampland habitats to groundwater-dependent and/or dryland vegetation types becomes increasingly apparent. In many instances the lack of inundation and variable depth to impeding layers (often beneath the sand sheet) adds significant complexity to the task of delineating the present-day dampland as the boundaries are often subtle and gradational.

The lack of detectable surficial (perched) groundwater during summer months suggests that dampland vegetation may in some instances be soil moisture-dependent, rather than being necessarily dependent upon free groundwater or access to the capillary fringe (phreatophytic) per se.

The incidence of gley soils beneath the Zeus wetland is indicative of hydric soils subjected to saturation and anaerobic conditions. Where gley soils, clays or impeding siliceous pans occur within 4 metres of the surface, dampland habitat is commonly expressed. This association has aided delineation of the Zeus wetland through application of a digital elevation model (DEM) in association with ground-truthing (Blandford, 2007).

Potential impacts to Wetlands are described in Table 6. The key risks, potential impacts and proposed management associated with Wetlands is covered in Sections 6.3 and 6.4.

4.11 Hydrogeology

4.11.1 Geology

A simplified surface geology map is presented as Figure 4.11.1, adapted from Mory (1995). In the area of the proposed mines the surface geology consists of superficial formations of Quaternary-Tertiary age that extend to depths of 20-60 metres below ground. The superficial formations overlie the Yarragadee Formation which extends to approximately 1 km depth. The Mesozoic and Permian strata of the Perth Basin in total extend to depths of more than 3 km in this area.

The Geological Survey of Western Australia investigated the hydrogeology of the superficial formations and the uppermost Yarragadee Formation between Leeman and Dongara with the Leeman Shallow series of monitor bores (prefixed LS on Figure 4.11.1) that were drilled to depths up to 100 metres. The findings from these bores were reported by Nidagal (1991 and 1995). The sediments of the superficial formations in downward order in the area of the proposed mines comprise Bassendean Sand (Quaternary age), Guildford Formation (Quaternary age) and Yoganup Formation (Tertiary age). The Bassendean Sand is a medium-grained sand of aeolian origin and is present only at and near the ground surface to depths of less than 10 metres. The Guildford and Yoganup Formations are comprised mainly of sand and clayey sand. The Yoganup Formation is a shoreline deposit representing a buried prograding coastline of dunes, beach ridges and deltaic deposits.

The Yarragadee Formation is of late Jurassic age. In 2008 Tiwest explored the Yarragadee strata to 229 metres depth near Department of Water bore site LS32 between the Heracles and Dionysus deposits. Geophysical logs show that about one-third of the thickness of the Yarragadee Formation to that depth is sand. Drill cuttings show that the sand is of medium to coarse grain size. The sand occurs as both thin beds (typically 1 metre thick) and thick beds (typically 6 metres thick). The other two-thirds of the total Yarragadee thickness drilled is clay and shale. The Yarragadee strata dip gently to the east in the area of the mines. This has been shown by correlations of geophysical logs between bores and also by seismic sections produced as part of oil and gas exploration in the area.

Several faults in the Mesozoic strata have been delineated by Mory (1994, 1995) on the basis of seismic data (Figure 4.11.1). Most are aligned approximately NNW-SSE.

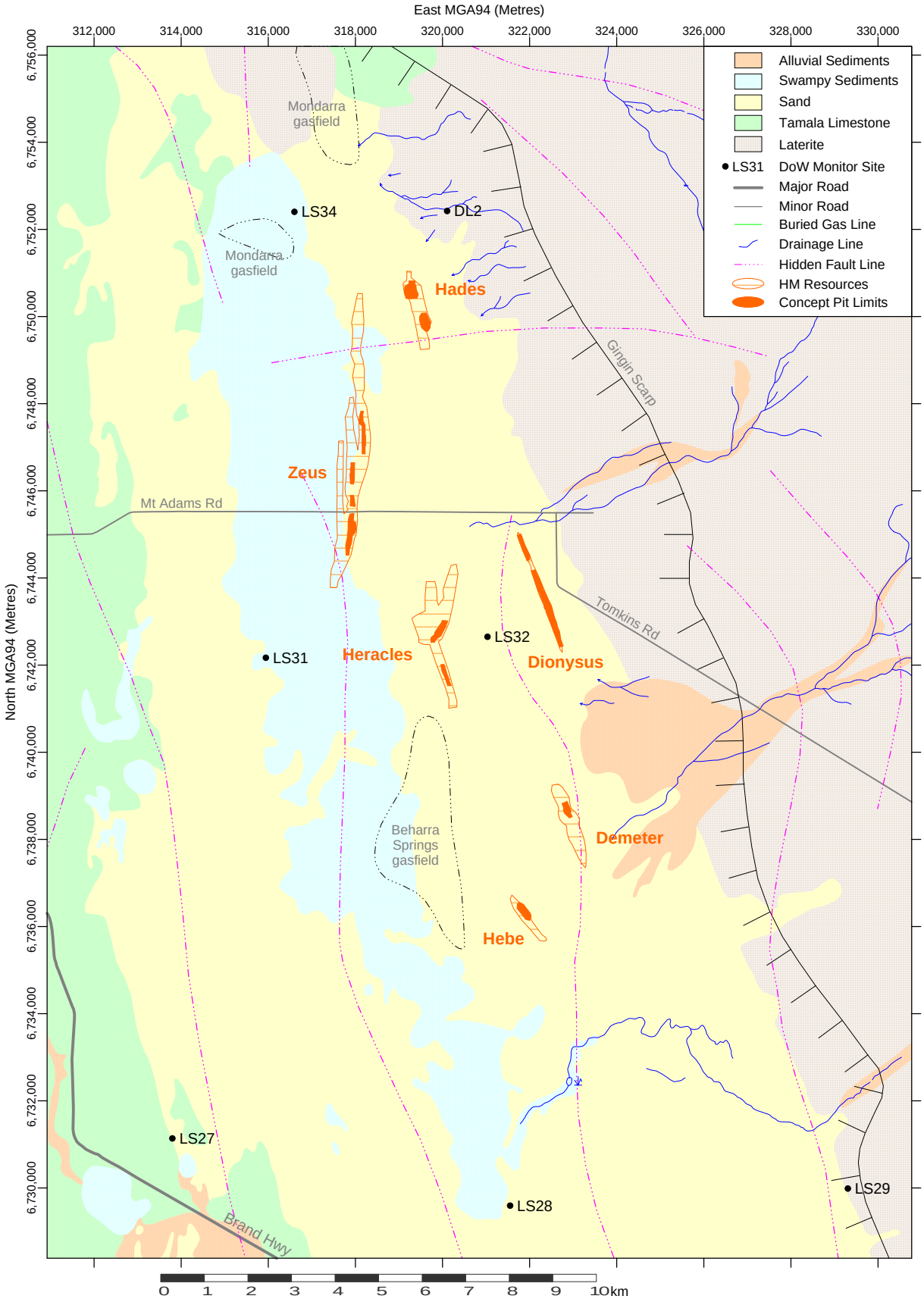


Figure 4.11.1: Simplified Surface Geology adapted from Mory (1995)

4.11.2 Groundwater in the Superficial Formations

Tiwest has installed a pair of observation bores DOB01 and DOB02 and a production bore DPB01 in the superficial formations for pump testing at the Zeus orebody, and a number of 20-mm piezometers within air core exploration holes throughout the region. These are shown on Figure 4.11.2.

In the area of the proposed mine sites both the ground surface and the base of the Superficial Formations slope downward to the west at typically 1.5 metres vertical per 100 metres horizontal. This is about double the westward slope of the water table. The base of superficial formations intersects the water table slightly west of bore LS32A, so that beneath the eastern mine sites of Hades, Dionysus and Demeter the superficial formations are totally above the water table. Figure 4.11.2 shows that the saturated thickness of the superficial formations increases westward to about 20 metres at Zeus, and reaches a maximum of about 28 metres further west. The depth to groundwater is 30-40 metres at the eastern mine sites, decreasing to 10 metres at Zeus and to less than 2 metres near bore site LS34 north-northwest of Zeus.

Figure 4.11.2 also shows the areas of superficial groundwater salinity greater than 1000 mg/L total dissolved solids. The salinity of the groundwater in the superficial formations increases westward as a result of concentration by evapotranspiration as it passes beneath the low-lying ground west of the Zeus ore body. The total dissolved solids (TDS) range from 420 mg/L at site LS34 to 1680 mg/L at site LS31. The water is slightly acidic with pH 6.0-6.5.

The 48-hour pump test carried out by Tiwest in DPB01 provided a transmissivity of 70 m^2/d for the unconfined aquifer. This value represents a combination of the sands of the superficial formations and a thin sand aquifer of the Yarragadee Formation that is in direct hydraulic contact with the superficial formations at that site.

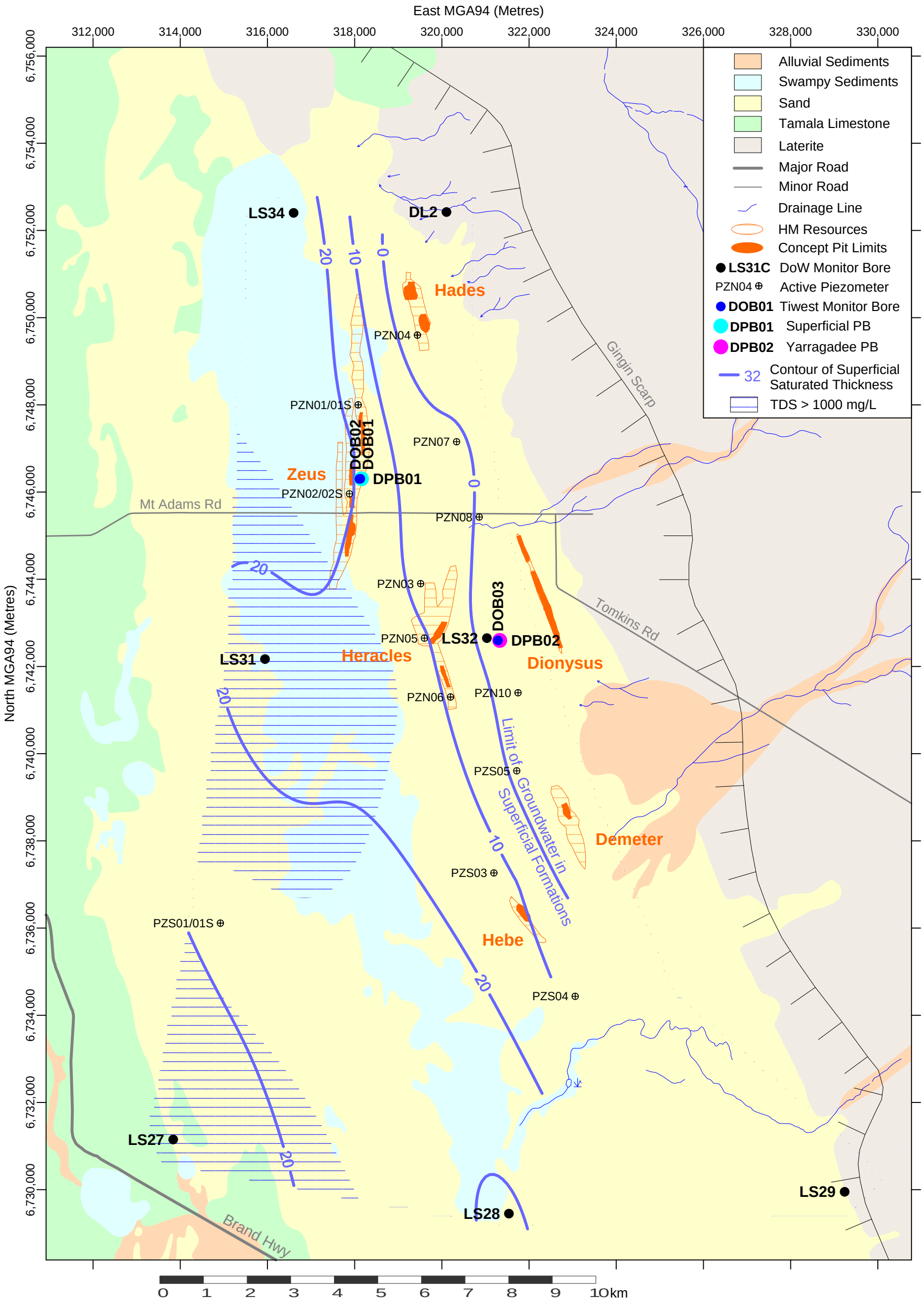


Figure 4.11.2: Saturated Thickness and Area of TDS > 1000 mg/L in the Superficial Formations

4.11.3 Groundwater in the Yarragadee Formation

The sand strata in the Yarragadee Formation constitute semi-confined to confined aquifers. The degree of confinement of the aquifers increases with depth. The uppermost Yarragadee Formation aquifers are hydraulically connected to the Superficial Formations at places where the dipping aquifers subcrop on the base of the Superficial Formations.

Near LS32 Tiwest has installed an observation bore DOB03 and a production bore DPB02 in the Yarragadee Formation. DPB02 is screened from 99-114 metres depth in an aquifer that has 17 metre thickness of sand. The transmissivity interpreted from the 48-hour pump test on the bore is 160 m^2/d and the hydraulic conductivity of the sand 9.4 m/d (Haselgrove, 2008). The Yarragadee aquifers are suitable for the bore water supply for the mining operations as they can provide high bore yields with relatively low risk of impacting on groundwater-dependent vegetation.

The groundwater in the shallow Yarragadee aquifers is relatively fresh, with TDS increasing from 420 mg/L at bore site DL2 in the northeast (Figure 4.11.2) to 960 mg/L at site LS27 in the southwest. The water is slightly acidic with pH 6.0-6.5. The salinity is higher at greater depth: bore DL2A screened from 421-427 metres depth has TDS 1690 mg/L whereas the adjacent bore DL2W screened from 63-69 metres depth has TDS only 420 mg/L.

4.11.4 Current Groundwater Users

There is no existing groundwater allocation greater than 8000 kL/year within 7 km of the proposed Tiwest wellfield. Within 7 km are scattered small allocations up to 8000 kL/year for Arc Energy and Origin Energy. It is not clear whether these are still in use. At about 7 km northwest of the northernmost proposed Tiwest bore is a moderate allocation from the Yarragadee Formation of 350,000 kL/year presumed to be for agriculture. There are no other significant allocations within reasonable proximity to the proposed Tiwest wellfield. Approximately 17 km east of the proposed wellfield the Murion Pastoral Company has an allocation of 5,000,000 kL/year from the Yarragadee Formation in the Twin Hills subarea. In summary there is little allocated use of groundwater in the vicinity of the proposed Tiwest wellfield.

4.12 Heritage

Aboriginal Heritage Surveys were conducted in the area during 1999, 2001, 2003, 2007 and 2008 (see listing below). An Ethnographic Heritage Survey of the Dongara Mineral Sands Project with Amangu Traditional Owners was conducted in August 2008. The Survey was commissioned by Tiwest in order to identify any Aboriginal Sites and cultural materials that may be impacted by proposed developments. The survey did not identify any new sites or areas of cultural heritage significance.

Consultation with the relevant Native Title Claimants, the Amangu Group (claim WAD6002/04) via the Yamatji Barna Baba Maaja Aboriginal Corporation, was resolved by the Dongara Project Agreement. The Consent to Grant of mining leases included in this agreement resulted in the granting of the mining leases during 2008 shown in Figure 1.2.1. Provisions are made within this agreement for the identification and protection of any Aboriginal heritage. Relevant commitments of the Dongara Project Agreement will be included in the PER document.

Searches of the DIA Register system indicates that there are no heritage sites within the proposed mining tenements. One site is in the locality south of the project area (refer Figure 4.1.1). This will not be disturbed during the proposed mining activities.

No non-indigenous heritage is known from or expected to occur within the tenements.

Heritage surveys conducted over the project area and immediate surrounds:

Yamatji Land and Sea Council 2008, Preliminary advice following an Ethnographic Heritage Survey of the Dongara Minerals Sands Project with Amangu Traditional Owners. Letter Report to Tiwest 27 October 2008.

Yamatji Land and Sea Council / Mr Stephen Corsini 2007, Preliminary advice of a Heritage Survey over a Proposed Infill drilling Program, Tenement E70/1592, E702263 and E70/2347, 30km southeast of Dongara. Report to Tiwest.

Quartermaine Consultants 2003, Report on an archaeological investigation for Aboriginal sites Denison 3D seismic programme. Report for Arc Energy Pty Ltd.

O'Connor, R. 2003, Report on Ethnographic Survey of the Proposed Denison 3D Programme. Report for Arc Energy Pty Ltd.

Quartermaine Consultants 2001, Archaeological survey report Origin Energy seismic exploration areas Hibbertia 3D and Ularino 2D Dongara, Western Australia. Report for Arc Energy Pty Ltd.

O'Connor, R. 2001, Report on an Ethnographic survey of the Proposed Hiobbertia 3D and Ularino 2D seismic Programmes. Report for Origin Energy Resources Pty Ltd.

O'Connor, R. 1999, Report on a survey for Aboriginal Ethnographic site at Beharra Springs 1999 3D seismic survey area. Report for Arc Energy Pty Ltd.

Quartermaine Consultants 1999, Report of an archaeological study of proposed seismic programme, Beharra Spring. Report for Boral Energy Pty Ltd.

5. RELEVANT ENVIRONMENTAL FACTORS AND IMPACTS

Key environmental factors and associated impacts relevant to the Dongara proposal have been determined by environmental referral documentation and subsequent preliminary studies, field surveys and discussion with stakeholders.

5.1 Environmental Factors

Environmental Factors and Potential Significant impacts identified by the EPA and DEWHA as relevant based on referral information were:

- Threatened Flora
- Threatened Fauna
- Alterations to Groundwater impacting threatened flora and fauna
- Clearing of habitat for threatened flora and fauna
- Land degradation (potentially acid forming soils)
- Air quality

5.2 Environmental Impacts

Potential significant effects identified by EPA and DEWHA:

- Loss of vegetation and fauna habitat
- Potential to encounter pyrite acid formation
- Impacts of dewatering and mine tailing on groundwater, habitat and habitat rehabilitation
- Road transport – dust issues

Areas of study for the environmental impact assessment have been identified for inclusion in the Public Environmental Review document. Potential impacts and reference to planned studies for all environmental factors relevant to the proposal are summarised in Table 11. Section 6 provides further detail of the planned studies and proposed management to address potential environmental impacts. Relationships between Environmental Impact Assessment principles, environmental factors, environmental objectives, investigations and proposed management are tabulated in Section 11.

Table 11 Key Environmental Factors, Potential Impacts and Studies Proposed

Factor	Potential Impacts	Studies Proposed & Reference
BIOPHYSICAL		
Flora	• Clearing of significant/poorly represented flora species and vegetation communities • Groundwater drawdown impacting listed threatened species or poorly represented species/communities • Introduction of weeds and dieback into adjacent vegetation • Dust generated from mining activities impacting on adjacent vegetation	Yes, Section 6.1 Yes, Section 6.4 Yes, Section 6.1 No, minor issue manage via Section 6.7
Fauna	• Loss / fragmentation of habitat by clearing, groundwater drawdown, unsuccessful rehabilitation or contamination of soil for listed threatened or significant species. • Impacts to subterranean fauna due to mining or groundwater drawdown • Direct injury or fatality from impact during clearing and with vehicles equipment in transport corridors • Increase in presence of and predation by introduced species	Yes, Sections 6.1, 6.2 and 6.4 Yes, Sections 6.2 and 6.3 Yes, Section 6.2 Yes, Section 6.2
Wetlands (wetlands, rivers)	• Reduction of wetland (ephemeral damplands) value and/or vegetation due to clearing, groundwater drawdown and/or alteration of ground water quality.	Yes, Sections 6.1, 6.3, 6.4 and 6.5
Water (surface or ground)	• Alteration of surface and sub-surface groundwater flow • Abstraction for water supply and mine dewatering	Yes, Section 6.3 No, Section 6.4
Land (terrestrial / landform)	• Unsuitable landform and soil profile re-construction post mining	Yes, Section 6.8
Land (marine)	Not relevant, project not near the coast.	No, not relevant
Conservation Areas	• Offsite Impacts to Yardanogo Reserve	Yes, Section 6.1
POLLUTION MANAGEMENT		
Air Quality	• Dust from mining, road transport and wind erosion	No, Section 6.7
Water Quality (surface, marine or ground)	• Alteration of water quality due to mining (acidification from potentially acid forming soils) or abstraction	Yes, Section 6.5 and Section 6.4
Soil Quality	• Excavation or exposure of acid forming soils during mining or groundwater abstraction/mine dewatering	Yes, Section 6.5
Noise	• Adverse impacts on neighbour amenity	No, Section 6.10
Radiation	• Increase exposure of community and general environment to radioactive materials excavated during mining	No, Section 6.9
Light	• Lightspill impacting fauna	No, minor issue
Greenhouse gases	• Increased emissions of substances that	No, Section 6.7

Factor	Potential Impacts	Studies Proposed & Reference
	contribute to human induced climate change	
SOCIAL SURROUNDS		
Heritage	• Nil identified	No, Section 6.6
Visual Amenity	• Poor site rehabilitation	No, Section 6.8
Recreation	• Nil – not relevant	No, not relevant
Risk	• Additional road traffic on Brand highway – Mt Adams to Cooljarloo • Interaction with oil and gas operator • Proximity to Dampier to Bunbury, Parmelia Natural Gas Pipelines and Beharra Spring oils/gas operator • Increased risk of bush fire	No, Section 6.11 (for all)
OTHER		
Decommissioning	• Site rehabilitation not meeting completion criteria loss of biodiversity and state liability	Yes, Section 6.8

5.3 Cumulative Impacts

There are a number of other projects within the region that are the subject of concurrent assessment or recent (last five years) approval. These were identified in Section 4.4. As these have similar environmental settings, factors and potential significant impacts, the assessment of cumulative impacts to relevant environmental factors from these other proposals and Tiwest's Dongara Project will be presented in the PER. This cumulative impact assessment will primarily focus on impacts to flora and vegetation, and associated fauna habitat.

6. PLANNED STUDIES & PROPOSED MANAGEMENT

This section sets out the scope of studies and investigation to be completed for each potential impact listed in Table 11 in compliance with EPA guidance documents. They also indicate, based on existing knowledge, where detailed management plans are likely to be generated in order to set out specific controls required for mitigating associated impacts. These may change as a result of the findings of proposed assessment studies. All proposed management plans listed in the following sections will be presented to the EPA and DEWHA with the final PER document.

For those environmental factors identified as not requiring additional studies and/or specific management, justification and supporting information will be provided in the PER document.

6.1 Regional and Local Flora and Vegetation

6.1.1 Key Risks

- Clearing and groundwater drawdown during mining activities resulting in impacts to the conservation status of listed threatened or significant species and/or poorly represented vegetation communities
- Introduction and spread of weeds and pathogens (specifically Phytophthora cinnamomi)
- Dust generation from mining activities impacting on vegetation.
- Off site impacts to Yardanogo Reserve

6.1.2 Study Methods

The project is located within an area known for its high level of ecological diversity and endemism as described in Section 4.6 and involves the clearing of vegetation in mining and rehabilitation (mulch harvesting) activities. As such, in accordance with the Environmental Protection Authority (EPA) document “Guidance for the Assessment of Environmental Factors No. 51” a Level 2 investigation is appropriate. This incorporates background research, a reconnaissance survey and a comprehensive survey specifically designed to enhance the level of knowledge at both the local and regional levels.

Proposed studies have been documented within Woodman 2007 and amended as set out in Woodman 2007a (Appendix B) in response to consultation with relevant Government representatives. To summarise this includes:

Impacts on Plant Communities

Local and Regional significance of plant communities will be addressed by quadrat based floristic analysis to support local scale mapping and impact

assessment. Quadrats will be established in locations representative of regi onal vegetation including conservation estate to address regional representation of communities. Data for the area from Iluka Eneabba and other sources will be used to provide adequate regional representation of the species and communities within Tiwest leases at Dongara. The Floristic Community Type (FCT) mapping will be utilised in the impact assessment and presented in the PER as discussed below.

Impacts on listed Threatened Species and Significant Species

Listed threatened and significant species in Section 4.6 will be mapped in the local area and their habitat requirements recorded. Impacts on those species that occur commonly in particular habitats will be addressed by quantifying impact to habitat and relating to regional data. Impacts on those species that do not occur predictably within particular habitats will be addressed by mapping populations in the local area and quantifying impacts on populations.

Existing regional data will be compiled from DEC and other Government and Industry sources (eg Iluka, ARC Energy, Origin Energy, and Agriculture Western Australia) and a conservation significance assessment for each species prepared. Selected regional searching for highly significant species may be conducted if warranted.

Weed and Phytophthora cinnamomi Hygiene

The project area will be inspected for weed species and estimates of cover recorded. A map of weed covers will be developed to provide a base for future weed hygiene planning.

The project area was first interpreted in 2006 to provide data to aid in hygienic drilling operations on the leases. It was assessed again in 2007. Dieback susceptibility for the Dongara project area will be mapped and included in the Dieback Management Plan.

Dust Related Impacts on Vegetation and Flora

The management approach proposed for minimising dust emissions is described in Section 6.7. Assuming the implementation of adequate dust control measures, the potential for dust emissions to significantly impact on flora and vegetation values in the area is not considered to be high. As such, no specific impact assessment studies are proposed.

Flora and Vegetation Impact assessment

The impact assessment for flora and vegetation to be conducted for the PER includes the direct and indirect impact on vegetation at a local (Dongara Study Area) and regional scale (Tiwest Study Area - Ore Reserves on both the Tiwest and Iluka leases and the vegetation surrounding the reserves). Flora surveys and flora community types analysis will provide the basis for the impact assessment in conjunction with studies completed by Tiwest for

the PER such as soil and soil landscape investigations, groundwater dependent ecosystem risk assessment, wetland mapping, hydrology, hydrochemistry and groundwater modelling. The Regional Study area will not extend beyond the area with FCT mapping. However, where required for cumulative impact assessment (such as due to the absence of floristic community type mapping), impacts will be assessed according to vegetation association and known species habitat (for conservation significant flora species).

Impact Assessment and study results will be used to quantify the potential cumulative impact of Tiwest's proposed mining on both conservation significant flora species, FCTs, vegetation associations of the region and fauna habitat.

Other Studies to address Mining Impacts on Vegetation and Flora

Other potential impacts to be considered in the above or separate studies include:

- Integration of vegetation and other (particularly soils) studies to develop integrated rehabilitation strategies (refer to Section 6.8).
- Impacts on vegetation from groundwater drawdown as a result of borefield extraction, pit or dredge pond excavation or dewatering affecting local groundwater (refer to Section 6.3 and 6.4).
- Impacts on vegetation from interference with local surface drainage patterns.
- Impacts on vegetation and significant flora species during the collection of mulch for rehabilitation (refer also to Section 6.8)
- Impacts on vegetation and significant flora species by acid sulphate soils (Section 6.5.2)

The field components of the studies proposed above were completed during spring of 2007. However, below average rainfall during the two years has resulted in ephemeral wetlands not containing sufficient water to promote germination of annual flora species. Ephemeral wetlands are recognised as often containing unique suites of flora dependent on period and depth of inundation. As such, additional investigation of these areas was undertaken during 2008. This involved:

- Re-visit floristic sampling quadrats in ephemeral wetlands in the project area to record annual flora taxa during winter then spring.
- Re-analyse floristic quadrat data to determine whether the wetland floristic community type groupings are altered by the data.
- Modify floristic community type maps and prepare a report detailing results of the work.

The results and findings of local and regional flora and vegetation investigations will be presented in the PER.

6.1.3 Proposed Management

Based on the findings of the studies, changes will be made or management strategies incorporated into proposed management plans to minimise the potential impacts of the project.

A Rehabilitation Plan will be developed that is consistent with EPA Guidance Statements No. 6 and No. 55 addressing:

- Control of clearing activities to minimise footprint and impact to significant species, and ensure availability of quality rehabilitation resources required,
- apply information provided in Water and Rivers Position Statement: Wetlands (WRC 2001), Guidance Statement No. 33 and Environmental Guidance for Planning and Development (EPA 2008) as relevant/practicable,
- The definition of a Rehabilitation objective (final landuse), for the unallocated Crown Land,
- The practices to be implemented during the project to maximise the quality of Rehabilitation outcomes in pursuit of that objective addressing all aspects of achieving the stated objective,
- A plan to manage the potential impacts associated with harvesting of mulch for rehabilitation (refer also to Section 6.8).
- Specific rehabilitation strategies for the management and return of significant flora and fauna species and communities or identified recalcitrant species (where required),
- Strategies for progressive rehabilitation as practicable throughout mining, and
- Preliminary completion criteria for key aspects of rehabilitation based on completion criteria developed for Cooljarloo and findings from studies and strategies developed for this project. Development of completion criteria for soil and soil landscapes in relation to other environmental factors is included in Section 6.8.2..

Other Management Plans that will be developed and submitted with the final PER document:

- A weed and P. cinnamomi hygiene management plan addressing risk with appropriate management strategies based on a dieback susceptibility map.
- A Dust Management Plan addressing the control of dust to minimise impacts on flora and vegetation (refer also to Section 6.7)

6.2 Fauna

6.2.1 Key Risks

- Habitat loss / fragmentation due to clearing, changes to hydrology (eg groundwater drawdown or changes to groundwater quality impacting subterranean fauna, unsuccessful rehabilitation or contamination of the soil)
- Direct injury or fatality from impact during clearing and with vehicles equipment in transport corridors
- Obstruction to fauna movement (pipelines)
- Increase in presence of and predation by introduced species
- Impacts to the status of conservation species.
- Impacts to subterranean fauna due to mining or groundwater drawdown

6.2.2 Study Methods

Terrestrial Fauna

The project location, together with the nature of the proposal, necessitate an assessment in accordance with a Level 2 survey (desktop study, reconnaissance and detailed survey) as set out in EPA Position Statement No. 3 (EPA 2002).

The aims of fauna assessments such as this include:

- review the list of fauna from Section 4.6 expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present;
- identify significant or fragile fauna habitats within the study area;
- identify any ecological processes in the study area upon which fauna may depend;
- identify general patterns of biodiversity within or adjacent to the study area, and
- identify potential impacts upon fauna and propose recommendations to minimise impacts.

As such, the assessment studies will incorporate:

- a “desktop study” comprising a literature review and predictive assessment of the fauna of conservation significance that are likely to be impacted by the Dongara operations and a preliminary field reconnaissance.
- followed by a detailed field survey to confirm the presence (or assess the likelihood of presence) of these species of conservation significance, to develop an understanding of the fauna (and fauna related issues) of the general area and to collect data that may assist in the environmentally responsible planning of the project.

Surveys conducted to date by Bamford Consulting Ecologists have highlighted areas that warrant specific investigation. These, and the nature of proposed studies, include:

Carnaby's Cockatoo

This species is listed as endangered under the EPBC Act and the WA Wildlife Conservation Act. Flocks of 3 to approx. 350 birds were seen throughout the site, mainly feeding on the heathland vegetation. The only suitable breeding sites within the study area but outside the project area (Figure 4.1.1) are the large Eucalypts around the old algae farm (Beharra Springs), however it is likely that these would be utilised instead by the Galahs (Eolophus roseicapilla) and Corellas (Cacatua sp.) that are abundant at the site.

Areas adjacent to the project area (such as in Yardanogo Nature Reserve (Figure 4.1.1)) will be reviewed for presence of suitable nesting hollows.

Western Groundparrot

The Mt Adams area and surrounds contain large contiguous areas of habitat suitable to support Western Groundparrots (Pezoporus wallicus flaviventris) that have remained (at least in part) unburnt for a number of years. A "reasonably reliable" sighting of this species was reported in 1992 at Mt Adams. As such, specifically targeted field surveys were undertaken within the project area during May/June of 2008. The survey team included various experts from DEC, Birds Australia and was coordinated by MJ Bamford. No sightings were recorded.

Invertebrates

Invertebrates in general are beyond the scope of assessment for environmental impact assessment because there are so many species and their taxonomy is so poorly understood, but it is possible to focus on a small range of taxa that are short-range endemics. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish).

It is possible that the seasonal wetlands present within the study area support populations of short-range endemic invertebrates. This could include aquatic species but also species of fringing environments that act as a mesic refuge.

Targeted sampling will be undertaken to locate such species. Studies will also be undertaken to determine the extent of habitat and degree to which this will be impacted by the proposal to enable an

assessment of the significance of potential impacts to relevant invertebrate species.

Subterranean Fauna

Proposed mining at the Zeus, Heracles and Hebe ore bodies will almost certainly intersect the superficial groundwater systems present at Dongara, thereby necessitating some dewatering. This in turn, may adversely impact potential habitats for subterranean fauna through groundwater drawdown.

EPA Guidance Statement 54a indicates a low likelihood of significant subterranean communities being present within the Dongara Project area (EPA 2007). However, it should be noted that surveys in the region are limited (W Humphreys, WA Museum pers com).

With a low likelihood of stygofauna in the project area, an appropriate sampling effort will be employed to demonstrate the perceived low risk to stygofauna during EIA. The proposed investigation aims to identify whether stygofauna are a relevant environmental consideration for the Dongara Mineral Sands Project.

A Pilot Study has been completed, followed by initial field sampling for stygofaunal communities from suitable established bores in accordance with EPA Guidance Statements No. 54 and No. 54a. Results from the pilot study and field sampling were inconclusive, therefore, further studies in accordance with EPA Guidance Statement 54a (EPA, 2007), are being undertaken.

Impact assessment

Impacts to fauna habitat will be investigated under the flora and vegetation impact assessment detailed in Section 6.1.2 with other studies such as those in Section 6.1.2 for clearing and mulch, Sections 6.3.2 and 6.4.2 for groundwater drawdown, Section 6.5.2 for acid sulphate soil, Section 6.7.2 for dust and Section 6.8.2 for landform reconstruction. The results of the impact assessment and associated fauna surveys will be included in the PER.

6.2.3 Proposed Management

Requirements for fauna habitat re-establishment will be incorporated into the Rehabilitation Plan and completion criteria. The Rehabilitation plan will consider impacts on fauna habitat associated with mulch harvesting.

A Fauna Monitoring Plan addressing ongoing monitoring requirements, as identified in impact assessment, to support impact mitigation measures and demonstrate recovery of habitat.

Potential impacts to habitat associated with groundwater drawdown will be addressed in a Groundwater Management Plan (Section 6.4.3) and other management plans as required.

6.3 Hydrology

6.3.1 Key Risks

- Groundwater drawdown from mining occurring in close proximity to ephemeral damplands (immediately west of Zeus) and minor drainage line (north of Dionysus).
- Alteration of surface and subsurface flows has the potential to impact dependant ecology (especially vegetation) and wetland values through erosion, edge effects, weed invasion and loss of ecological linkages

6.3.2 Study Methods

Due to the likelihood that wetland vegetation on the site is believed to be (at least) seasonally groundwater and/or soil moisture-dependent, drawdown of the superficial aquifer is likely to impact on the Zeus wetlands. Further studies and investigations will be conducted to evaluate wetland impacts from drawdown. The results from these will verify the hydraulic assumptions underpinning groundwater drawdown modelling and inform development of a Groundwater Management Plan for the site.

Specifically, further studies and investigations will map and characterise wetland areas and dependencies with respect to surface and subsurface hydrology. Wetland identification, delineation, classification and evaluation methods in Hill et al. (1996a), V & C Semeniuk Research Group (1998) and EPA Bulletin 686 A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area (EPA, 1993) and the draft Framework for mapping, classification and evaluation of wetlands in Western Australia (DEC 2007) will be applied in studying the Dongara project area. Ecological value will be mapped as part of the flora (Section 6.1) and fauna (Section 6.2) studies. Potential for impact resulting from groundwater drawdown are addressed in Section 6.4.

6.3.3 Proposed Management

A Surface and Groundwater management plan will be developed addressing impact mitigation and monitoring strategies required for wetland management that is consistent with EPA Position Statement No. 4 and EPA Guidance Statement No. 33. Refer to Section 6.4.3 for more detail.

Rehabilitation Plan will address requirements for rehabilitation of areas mined in terms of maintaining hydrological features. Refer to Section 6.1.3 for more detail.

6.4 Hydrogeology

6.4.1 Key Risks

- Groundwater abstraction reducing availability of water for other users
- Groundwater abstraction reducing water availability thereby impacting groundwater dependant ecology especially vegetation and fauna.
- Drawdown from mine pit dewatering and water abstraction causing deterioration in groundwater quality by oxidation of acid sulphate soils.
- Mounding of the water table as a result of infiltration of slurry water from slimes disposal areas.

6.4.2 Study Methods

A desktop review was undertaken to characterise the hydrogeological setting of the project area via review of previous studies including (but not limited to) available drilling data (Tiwest and other site users) and existing data from Department of Water. This study will provide the basis for the development of a conceptual hydrogeological model and site water balance for the site.

Groundwater exploration in both the superficial and Yarragadee aquifers has been undertaken to determine prospective yields for abstraction and to assist in developing a supply strategy for the project. In addition pump testing has been conducted on abstraction bores in the superficial and Yarragadee aquifers to assess the potential for groundwater drawdown.

Additional piezometers were installed to the west of the Zeus and Heracles deposit in 2008 to better define the background water table depth, groundwater quality and flow directions. These along with previously installed monitoring bores and piezometers are shown in Figure 6.4.1.

Hydrological modelling will be undertaken incorporating baseline aspects for the project area based on the known geology, topography, groundwater and surface water interaction and recharge and discharge zones. The model will be populated with data from existing literature and data from previously completed studies (by Tiwest and others). The model will identify potential zones of influence of mining on the water table from pit dewatering, process water supply, tailings disposal and diverted stream flow. It will also simulate cumulative drawdown associated with abstraction for the proposed Yarragadee borefield and mine pit dewatering.

Once the model has been calibrated, three mine schedule scenarios will be incorporated into the model using MODFLOWs drain function. A report of the modelling will detail the Dongara groundwater model set up and sensitivity analysis, maps of predicted drawdown in the superficial aquifer at the end of each mining stage and a map of maximum drawdown. The volume of groundwater abstracted via pit dewatering will also be reported.

An ecological risk assessment will be undertaken which will define criteria for determining groundwater dependence of vegetation and map such areas within the project locality. Considerations will include depth to water table, soils profile and vegetation species present. The risk assessment will determine from the modelling studies, where and by how much the decline in the water table from pit dewatering and mine water supply bores may exceed acceptable risk levels for groundwater-dependent vegetation and fauna.

Acidic Soils investigations and management is addressed in Section 6.5.

6.4.3 Proposed Management

- An operating strategy and monitoring program for the Yarragadee production wellfield will be submitted to the Department of Water before the wellfield is commissioned.
- The studies described in the previous section and in Section 6.1.2 will characterise likely drawdown risks and associated potential for impacts to groundwater dependant ecology and habitat for flora and fauna due to mine dewatering. Outcomes of this will be used to develop a Surface and Groundwater Management Plan for the monitoring and management of drawdown related impacts.
- The Surface and Groundwater Management Plan will address management of groundwater abstraction from the Superficial and Yarragadee Aquifers including:
    - strategies for minimising water consumption and maximising reuse;
    - contingency actions to be implemented should hydrogeological conditions differ from what is predicted;
    - risk based monitoring program for water quality and quantity (water table levels) across the site; and
    - pollution management measures focussing on preventing and detecting spills and leaks of potential contaminants such as hydrocarbons, nutrients and process chemicals (eg flocculants).

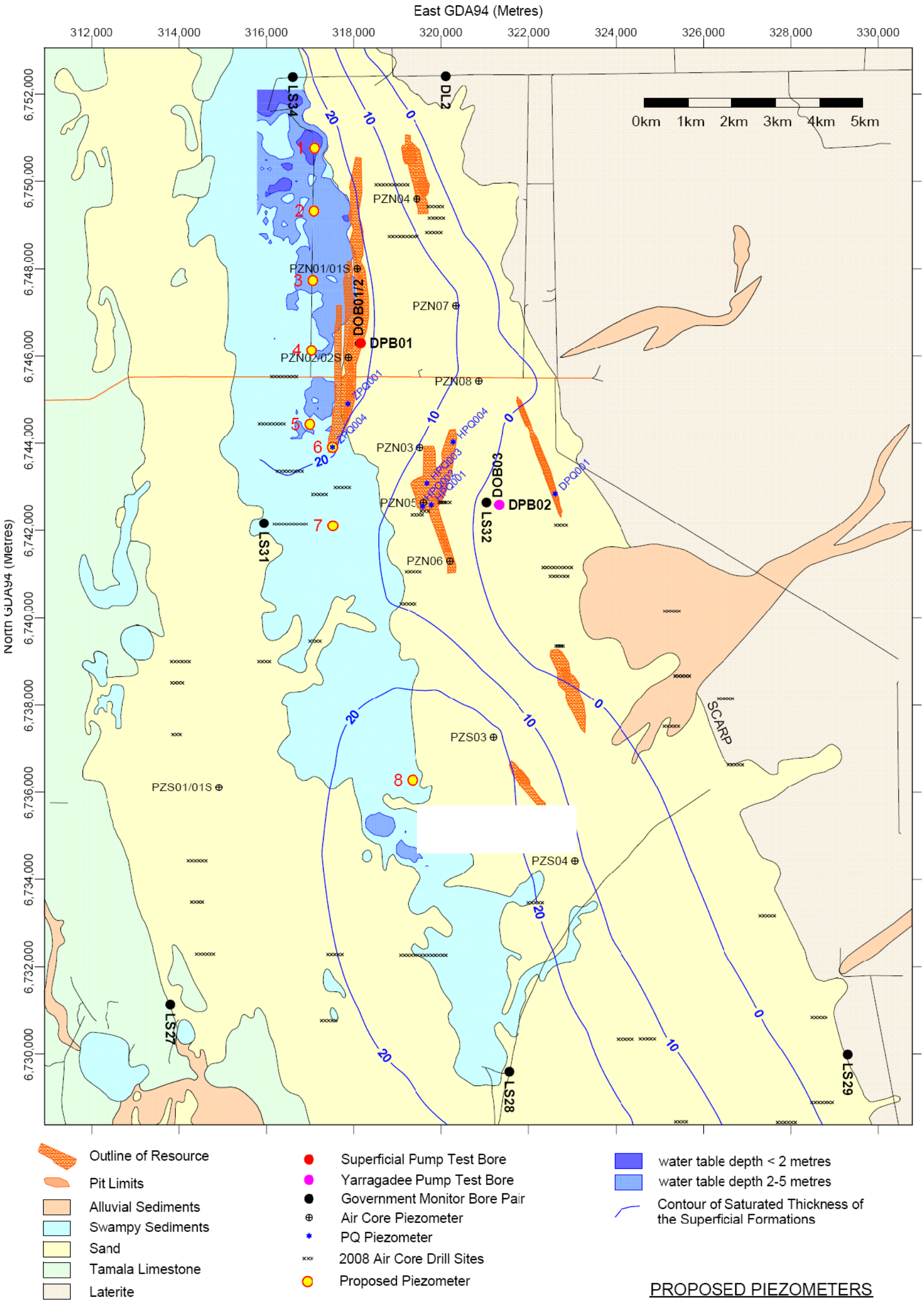


Figure 6.4.1: Test Bore Location and peizometers installed

6.5 Soil and soil landscapes

6.5.1 Key Risks

- Potentially acid forming soils that may be exposed during pit excavation and associated dewatering.
- Unsuitable reconstruction of landforms and soil profiles post mining

6.5.2 Study Methods

Acid sulfate soils have the potential to cause soil and water contamination through the acidification of soil water and resulting mobilisation of contained metals. It primarily results from oxidisation of sulfur bearing minerals (eg pyrite) generating sulfuric acid.

Mining activities proposed for the Dongara Project may expose potentially acid forming soils to oxidising conditions due to:

- excavation of materials from below the water table (perched or superficial formations) to the ground surface outside the saturated zone; and
- mine pit dewatering resulting in groundwater drawdown beyond the natural range.

Investigation methodology for assessing the risk from potentially acid forming soils during mining activities is set out within:

- DEC 2009, Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes; Acid Sulfate Soils Guideline Series, Land and Water Quality Branch, Department of Environment and Conservation, (DEC) Western Australia.
- DoIR 2006, Guidelines for Mining Proposals Department of Industry and Resources (DoIR) Western Australia

Neither standard deals in detail with requirements for minerals sands mining. As such, aspects of both approaches with adaptations will be applied.

Specifically, the investigation will involve drilling at a number of locations within and outside the proposed areas of mining, sampling across the soils profile at one metre intervals to a depth exceeding the proposed mining and modelled groundwater drawdown by at least two meters.

Samples will then be analysed for change in pH under rapid oxidation. Representative samples from each lithological unit within each drilling location will also be analysed via the SPOCAS technique to determine the acid forming potential. Samples identified by the pH change under rapid oxidation as potentially high risk will be selected as representative of the relevant lithological unit for SPOCAS testing.

The aim of the sampling program is to characterise the acid form potential of each lithological unit present within the mining area and immediate

surrounds. This information, together with detailed sampling undertaken to characterise the orebodies will then be used to model the extent of potentially acid forming units and thereby assess the risk and management requirements.

The first round of the acidic soil investigation is completed. The results indicated oxidisable sulphur was below 0.2 %. The second round of acidic soil investigations has also been completed in conjunction with metal analysis. This will be followed by a third round, based on recommendations from the DEC (pers. comm. Steve Appleyard), testing overall acidity of soils, level of base cation saturation, and readily exchangeable soluble aluminium. The full results of all three rounds will be reported in the PER.

Material characterisation and soil landscape assessment for the purposes of rehabilitation are addressed in Section 6.8.

6.5.3 Proposed Management

A Material Identification and Management Plan will be developed as a component of the Rehabilitation Plan based on the results from the above studies. The plan will outline procedures to identify materials and provide management strategies to deal with them effectively.

The requirement for an Acid Sulfate Soils Management Plan will be determined on the basis of results of soils testing. Should a plan be required it will be developed on the principles set out within relevant DEC (Draft Treatment and management of soils and water in acid sulfate soil landscapes 2009) and DMP guidelines.

6.6 Heritage

Potential impacts on Aboriginal Heritage have been addressed in accordance with EPA Guidance Statement No. 41. Areas of proposed mining have been surveyed in conjunction with representatives of the Amangu Group in association with the Yamatji Aboriginal Land and Sea Council. No heritage sites were identified. Procedures for the identification and preservation of Aboriginal heritage have been agreed as specified in Section 4.12.

Heritage management procedures reflecting these commitments will be developed for the project.

6.7 Air Emissions

6.7.1 Key Potential Issues

- Dust emission from mining activities and disturbed lands resulting in public nuisance and impacting vegetation.
- Combustion emissions contributing to human induced climate change.

6.7.2 Study Methods

Dust Emissions

Mineral sands mining can generate dust which, if not adequately managed, may adversely impact environmental values. Analysis of the composition of the overburden and ore materials at Dongara indicate that it is will most likely only present a risk in terms of physical processes including smothering of vegetation, nuisance / irritation of lungs, and aesthetic impacts.

Assessment of the risks associated with dust generated during mining activities will involve:

- Characterise the major constituents of the ore and overburden materials at site;
- Examination of the project location in relation to sensitive receptors (ie residences) and prevailing wind directions/speeds to assess the risk of dust impacts to these occurring; and
- Proposed effective dust control measures to be implemented and methods to monitor mitigation success.

Combustion Emissions

Emissions produced by the mining fleet, diesel tailings pumps and other combustion engines contribute to human induced climate change. Similarly, consumption of other forms of energy, and resources, including land clearing, carry similar potential.

While the duration and magnitude of this proposal is such that the resulting contribution to human induced climate change is negligible, the nature of the problem is such that a multitude of small scale contributions add up to produce significant combined contribution to pollution and related impact on a national or global scale. As such, Tiwest maintain programmes to track and improve efficiency and decrease combustion emissions.

For the Dongara project, the carbon emissions profile for the project will be quantified and improvement opportunities identified. These will be incorporated into business improvement systems.

6.7.3 Proposed Management

A Dust Management Plan will be developed addressing dust generation from road transport and mining activities

Develop greenhouse gas emissions inventory and management plan to monitor, report and reduce carbon pollution in line with the EPA Guidance Statement No. 12 – Minimising Greenhouse Gas Emissions, EPA 2002, National Greenhouse and Energy Reporting Act 2007, Energy Efficiency Opportunities Act 2006 and other Acts and guidelines as relevant.

6.8 Rehabilitation and Decommissioning

6.8.1 Key Risks

- Poor site rehabilitation leads to permanent loss of biodiversity and state liability
- Site rehabilitation not meeting completion criteria
- Unsuitable landform re-construction post mining

6.8.2 Study Methods

In undertaking the environmental review of this proposal, Tiwest will investigate requirements for the rehabilitation of disturbed areas post mining to an agreed final landuse. This will involve (but not necessarily limited to):

- Consultation with key stakeholders (DEC for uCL and the relevant landowner for the cleared freehold in the vicinity of Hades) on the final landuse/rehabilitation objective – at this time the base presumption is that uCL will be rehabilitated to a self sustaining native ecosystem and cleared freehold to pasture.
- Determination of rehabilitation criteria and documentation of supporting planning, works and monitoring practices to support delivery of the final landuse including:
  - Landform stability and soil profile development.
  - Topsoil Management.
  - Recruitment, Establishment and Propagule Strategies.
  - Mulch supply for rehabilitation.
  - Requirement for ecosystem rehabilitation, especially for conservation significant fauna.

The review will incorporate findings from studies of the pre-disturbance environment and will build on existing knowledge and experience obtained from Tiwest's Cooljarloo Mine and other operators as relevant. Findings from all relevant environmental studies will be used to identify key constraints and requirements for rehabilitation in accordance with EPA Guidance Statements No. 6 and No. 55. The proposed approach for addressing the key aspects of this are discussed in detail below.

In determining the requirements for ecosystem re-establishment, consideration will be given to what is desirable in terms of restoration of the pre-mining environment, and what is achievable with the resources available. In this, the return of the pre-disturbance environmental values and characteristics is an aspirational goal. However, consideration must be given to the changes mining makes to the environment, particularly

the soil landscapes, and the fact that within this context it will not be possible to restore the environment to its pre-disturbance state.

Landforms and Soil Profile Development

A review of studies conducted for the Dongara project by Blandford (2007 and 2008), will provide the technical basis for determining the key characteristics of the pre-disturbance soil landscape relevant to rehabilitation. This will also give consideration to how these materials will present and behave in the post mining environment. The aim of these studies will be to determine which landform characteristics are important to retain or re-establish in the post mining landform, what constraints are presented in the post mining materials (in terms of achieving the rehabilitation objective). Key issues specific to each ore body will be considered for:

- landform reconstruction;
- soil profile reconstruction;
- rehabilitation;
- soil-water relationships;
- soil-vegetation relationships;
- landform-soil-wetland interaction; and
- wetland hydrology-subsurface water flow.

From this a comprehensive data set will be formed to provide the basis for strategic planning, operational management and rehabilitation design. The dataset will be used in the design of post mining soil profiles, landforms and the material management strategies required to deliver the design.

Topsoil testing, analysis and management practices

Topsoil is a vital component of successful rehabilitation. It provides the media essential for vegetation establishment, landform function and stability and is generally the dominant source of flora and soil fauna propagules. Poor topsoil management practices, including characterisation, storage and placement, will, almost certainly, lead to poor rehabilitation outcomes. It is essential that the requirements for the characterisation, preservation and management of topsoil at the Dongara Project site is understood and incorporated into relevant management plans.

As such, the PER will involve the preliminary review and sampling of topsoil within the disturbance footprint. Based on the findings, requirements for detailed characterisation and management of topsoil will be determined and presented within the Materials Management Plan. This will include all orebodies as well as non-orebody areas.

Recruitment, Establishment and Propagule Strategies

Rehabilitation of flora and vegetation aims to return vegetation groups appropriate to post mining land capabilities and commensurate with pre-mining environment. This facilitates the establishment of ecosystems of

appropriate diversity and habitat value. Particular regard is given to the management of conservation significant flora and fauna species and their corresponding habitat requirements.

To address this area, investigation into the requirements for vegetation rehabilitation will include consideration of:

- Vegetation composition targeted and achievable in rehabilitation and what is required to meet rehabilitation objectives. This will also consider management expectation for particular environmental aspects (eg return of habitat requirements for fauna species, most notably Carnaby's Cockatoo).
- Recruitment strategies, propagule sources and planning required to ensure their availability and effectiveness.

Mulch for Rehabilitation

Mulched vegetation is used in native rehabilitation to:

- minimise wind erosion of topsoil and propagules (seed) prior to the establishment of vegetative cover;
- provide additional organic material and fauna refuges; and
- contribute propagules, together with topsoil and spread seed, to ensure an appropriate species mix is achieved.

Preferentially, material for mulching is sourced from within the mine footprint. In some circumstances the material available on mine path for mulch can be insufficient to meet rehabilitation needs. In such circumstances the shortfall could, and in the absence of any other viable alternative must, be sourced from harvesting vegetation in areas "off mine path".

Mulch is sourced via grinding (mulching) vegetation material removed from ahead of the mine or harvesting standing vegetation. Harvesting involves cutting and mulching of native vegetation down to a minimum height of 0.2 m using a custom built Forage Harvester. Mulch is collected and stockpiled for later use, or directly spread, in rehabilitation as required.

Further planning is required to determine the area of off mine path harvesting required (if any) for the Dongara project. However, it is expected that mulch will be required to be sourced from both within and outside the proposed mine footprint. As such, the studies for rehabilitation and vegetation clearing related risks will consider those potential impacts associated with harvesting of mulch beyond the footprint including:

- Estimation of the likely areas required to be harvested beyond the footprint for key vegetation communities:
- Examination of available data regarding the potential ecological impacts associated with harvesting activities and their significance especially for vegetation communities and significant flora species; and
- Develop appropriate management requirements.

Adoption of Rehabilitation practices from Cooljarloo Mine Site

Rehabilitated areas at Tiwest's Cooljarloo mine site are monitored and reviewed against previous year's results to indicate progress towards Interim Performance Criteria (IPC) Targets on an annual basis. Through the analysis of results by an external party, recommendations are outlined to improve rehabilitation performance. Key findings from these rehabilitation reviews will be incorporated into environmental planning for the Dongara Project.

Rehabilitation techniques and procedures at Cooljarloo have been continual improved through reviews, research and trials, and adoption of industry best practices. These rehabilitation techniques and procedures will be reviewed and adapted for the Dongara Project, ensuring practices used are applicable based on results of studies.

Completion Criteria and Associated Monitoring Program for Native Ecosystem Rehabilitation

Completion Criteria will be developed to demonstrate the reconstructed landforms provide the foundation for achieving Tiwest's rehabilitation objectives, taking into account any major limitations for rehabilitation and the environmental significance of the area identified during environmental studies. The criteria for the Dongara project will consider both what is desirable (or expected) and achievable based on Tiwest's experience at the Cooljarloo mine site as appropriate. A review of Cooljarloo's Completion Criteria and Associated Monitoring Program for Native Ecosystem Rehabilitation will contribute to the development of completion criteria for the Dongara Project.

6.8.3 Proposed Management

A Rehabilitation Plan will address requirement for rehabilitation of areas cleared during mining as outlined in Section 6.1.3 and associated with mulch harvesting outside the mine footprint as appropriate. Rehabilitation techniques and procedures and completion criteria developed as detailed in 6.8.2 will be included in the Rehabilitation Plan. For more detail also refer to Section 6.1.3.

A Material Identification and Management Plan will be included as a component of the Rehabilitation Plan that characterises and classifies materials required for use in landform reconstruction. This will include a topsoil sampling programme for the testing, analysis and management of topsoil.

Within the rehabilitation plan, a program will be developed for mulching to minimise impacts on vegetation in accordance with EPA Guidance Statement No. 55. This plan will include a monitoring program, proposed placement of mulch material stockpiles and review of existing information on mulching practices and rehabilitation to identify areas of improvement.

6.9 Radiation

6.9.1 Key Risks

- Increase exposure of community and general environment to radioactive materials excavated during mining

6.9.2 Impact assessment

As detailed in Section 2.4 the Dongara Project HMC contains naturally occurring radioactive elements, principally Uranium and Thorium and associated decay series. Monazite has the highest content of these radionuclides (Table 3) and constitutes on average 1.02% by weight of the Heavy Mineral Concentrate (HMC) in the Dongara ore bodies (Table 2). Other heavy minerals in the ore also contain thorium and uranium but at concentrations, in general, several of orders of magnitude less. The Uranium and Thorium content of Ilmentite and Rutile within the Dongara HMC are shown in Table 4. The ore bodies presented in Table 4, Dionysus, Heracles and Zeus, represent the greatest percentage of the Dongara HMC.

At such concentrations the risk to personnel, the wider public and the environment is low, and will be further mitigated through the development and implementation of a Radiation Management Plan. To develop this, in the first instance the radiological content of the Dongara ores will be examined against exposure standards and the pathways for potential exposure mapped. This will then guide the adaption of Tiwest's existing Northern Operations Radiation Management Plan to address the specifics of the Dongara project for submission to the Department of Mines and Petroleum.

Potential impacts to other environmental aspects such as habitat of threatened species and groundwater will be addressed as required in the PER and Radiation Management Plan.

6.9.3 Proposed Management

A Radiation Management Plan (RMP), based on that in place for the Cooljarloo Minesite, will be developed for the Dongara project area. Procedures and management of material will be included in the Radiation Management Plan based on characterisation of the material to ensure key objectives can be met.

Key objectives included in the RMP will be:

- to restore the surface of the mined area to the pre-operational radiation conditions.
- to manage sources of radiation to minimise exposure and contamination
- to monitor radiation control via aspects such as dust, water, personal exposure and area gamma radiation as appropriate.

6.10 Noise

6.10.1 Key Risks

- Noise impacts on neighbouring sensitive premises.

6.10.2 Impact Assessment

An acoustical assessment of the Dry Mine facilities at Cooljarloo North Mine, including modelling of environmental noise contours, was completed by Herring Storer Acoustics during March 2007 (Herring Storer 2007). This assessment modelled the combined noise emanations from the Dry Mine Feed Preparation Unit, pit (including mining machinery) and Concentrator on the basis of a "worse case" scenario from actual noise measurements. Results from this indicated that at distances greater than 1.5km environmental noise levels could be expected to be well below 30dB(A) (see Figure 6.10.1). The modelled data of the Cooljarloo Dry Mine facilities contains an inherent overestimation and the modelled contours are well within acceptable environmental noise limits.

The Dry Mine Feed Preparation Unit, or similar equipment, will be relocated to Dongara upon cessation of Cooljarloo North Mine. At Dongara there are no neighbours closer than 2.5km to the proposed concentrator or feed preparation unit sites. Based on acoustical assessment and modelling at Cooljarloo North Mine, it is expected there will be no adverse impacts from noise emissions during the project and it meets the requirements to comply with Environmental Protection (Noise) Regulations 1997. Therefore, modelling of environmental noise at Dongara will not be required.

6.10.3 Proposed Management

Noise emissions from the project are not expected to impact on nearby residents, will not create nuisance beyond the boundary and will comply with Environmental Protection (Noise) Regulations 1997.

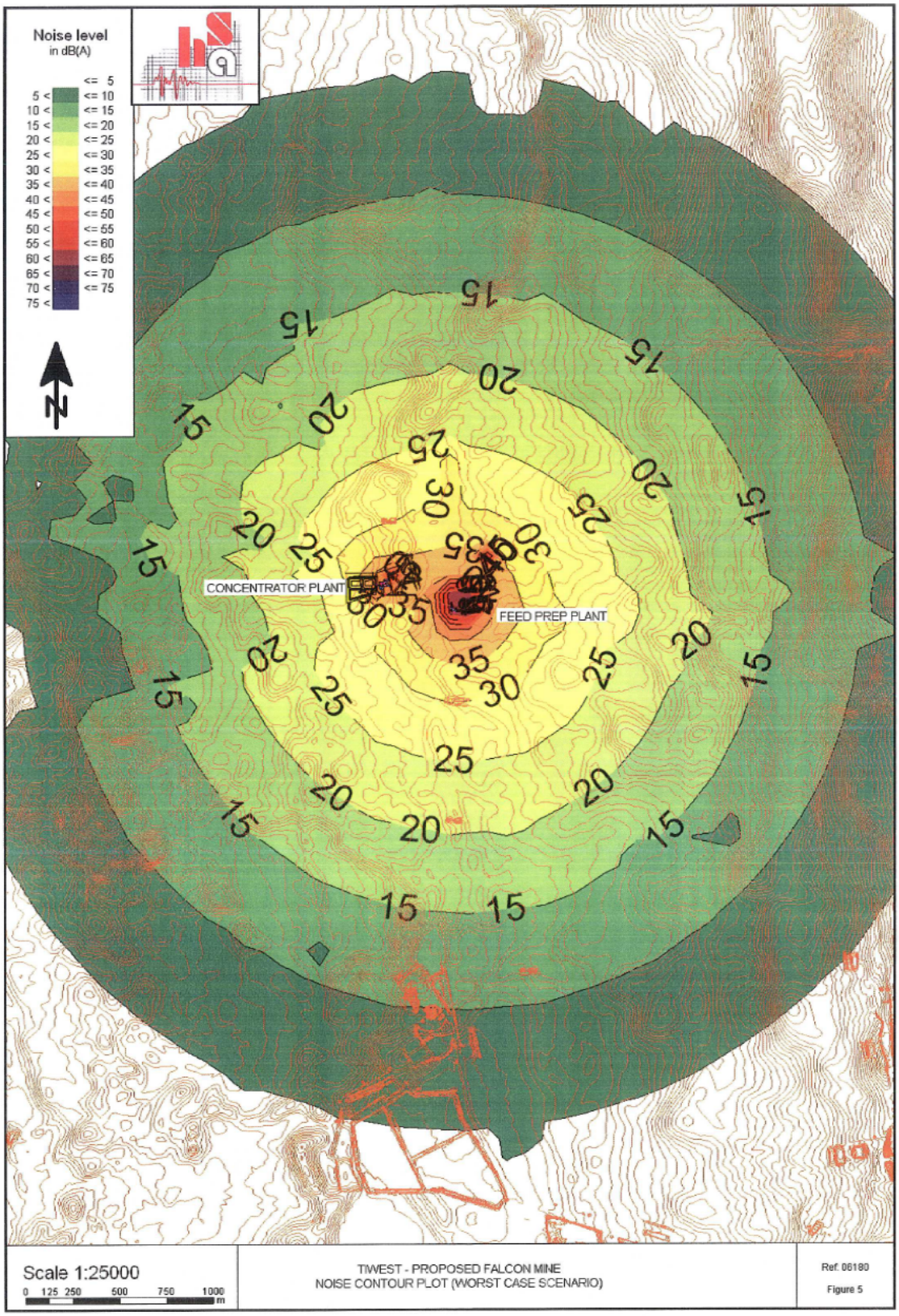


Figure 6.10.1 Indicative "Worse Case" Noise Contour Plot (from SVT 2007)

6.11 Fire Management

As the majority of the project area is uncleared heath and woodlands fire presents a risk to biodiversity, property and personnel. Maintenance of a mosaic of areas or varying burn ages, especially ensures that some areas remain unburnt for significant lengths of time it important for the preservation of flora species and communities and habitat for fauna species of the area.

On balance, this proposal is not expected to increase the risk of fire above existing levels. However, Tiwest recognise that they will bear some responsibility for fie control within the tenement. As such, in consultation with the DEC, a Fire Management Plan will be prepared and submitted with the PER. This will consider the objectives of fire management (eg preservation of biodiversity, property and personnel), strategies to achieve these and monitoring to demonstrate success or otherwise.

6.12 Waste Management

Poor management of wastes can impact on the environment and leave a lasting legacy with the community. Tiwest have active waste management programs at current operating sites to reduce the amount of waste disposed and periodically examine avenues for beneficial reuse, where possible. Dongara project site will have a similar waste management program to minimise environmental impacts.

The two main types of waste that will be produced at the Dongara Project site are process and non-process waste. Process waste are those wastes generated during the production of the product minerals and will be managed under the Material Identification and Management Plan (Section 6.5.3).

Non-process wastes are ancillary wastes generated to run the plant and include:

- General domestic waste and recyclables
- Waste oil and Grease
- Solid wastes – none process
- Sewerage
- Other non-process wastes

To effectively manage non processing wastes generated from the Dongara Project a Waste Management Plan will be developed according to applicable legislation and submitted with the PER.

7. ENVIRONMENTAL MANAGEMENT SYSTEM

Tiwest's commitment to environmental management and support for maintaining and improving community amenity is described in the Corporate Environmental Policy and supporting Corporate Environmental Performance Standards and SHE Systems Standards. These are the overarching goals that govern all Tiwest's operations and specifically the Cooljarloo mining venture and provide guidance on how it will be achieved.

In line with this Tiwest Northern Operations implements an integrated Safety Health and Environmental Management System (certified to ISO14001). The system is verified via annual certification audits, internal performance appraisal against Corporate Environmental Standards and through annual public environmental reporting.

These are based on the identification, assessment and management of risk within a regular review and continual improvement framework.

8. STUDY TEAM

Key members of the study team supporting Tiwest in this assessment and development of the PER comprise:

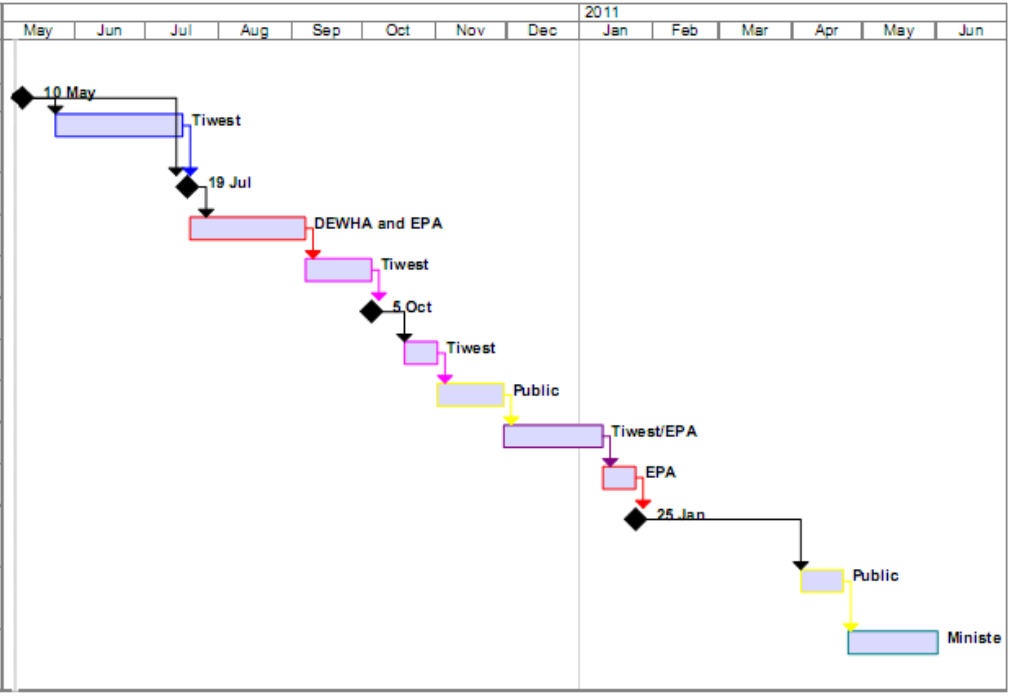
- MJ & AR Bamford Consulting Ecologists Pty Ltd (Fauna)
- DC Blandford and Associates Pty Ltd (Soils)
- Endemic Pty Ltd (Surface Water, Wetlands and Subterranean Fauna)
- Hydrosearch Pty Ltd & Geoprocc Pty Ltd (Groundwater and Hydrogeochemistry)
- Parsons Brinckerhoff Pty Ltd (Groundwater Modelling)
- Froend Bowen and Associates Pty Ltd (Groundwater Dependant Ecology)
- Rockwater Pty Ltd (Subterranean Fauna)
- Woodman Environmental Pty Ltd (Flora and Vegetation)

9. PROJECT AND ASSESSMENT SCHEDULE

On 4th September 2007, the Environmental Protection Authority set the formal level of environmental assessment as a Public Environmental Review. This Environmental Scoping Document (ESD) is submitted as part of the Dongara proposal referral. The proposed Project Assessment Schedule is listed in Table 12.

Table 12: Proposed timetable for the Dongara PER assessment process

ID	Duration	Resource Names	Start	Finish	Task
1	**122 days?**	**Tiwest**	**Mon 24/08/09**	**Tue 9/02/10**	**Submission of ESD to EPA & DEWHA**
11	10 days	EPA	Mon 10/05/10	Fri 21/05/10	Sign-off of ESD by EPA & DEWHA
12	40 days	Tiwest	Mon 24/05/10	Fri 16/07/10	Environmental Investigation and consultation (PER Drafting)
13	1 day	Tiwest	Mon 19/07/10	Mon 19/07/10	Submission of Draft PER to DEWHA and EPA
14	35 days	DEWHA and EPA	Tue 20/07/10	Mon 6/09/10	Review of PER by EPA and DEWHA
15	20 days	Tiwest	Tue 7/09/10	Mon 4/10/10	PER revision following EPA and DEWHA comments
16	10 days	EPA	Tue 5/10/10	Mon 18/10/10	EPA and DEWHA Accept PER
17	10 days	Tiwest	Tue 19/10/10	Mon 1/11/10	Organise release of PER to public
18	20 days	Public	Tue 2/11/10	Mon 29/11/10	Release of PER for Public review
19	30 days	Tiwest/EPA	Tue 30/11/10	Mon 10/01/11	Preparation of response to submissions
20	10 days	EPA	Tue 11/01/11	Mon 24/01/11	EPA assessment and report
21	50 days	EPA	Tue 25/01/11	Mon 4/04/11	EPA Report and recommendations published
22	14 days	Public	Tue 5/04/11	Fri 22/04/11	Appeal Period on EPA's report and recommendations
23	28 days	Minister/ Appeals Convenor	Mon 25/04/11	Wed 1/06/11	Minister considers EPA report & appeals



10. STAKEHOLDER CONSULTATION

10.1 Consultation with key stakeholders

Tiwest began consultation with key stakeholders regarding the Dongara Project via meetings and community events since 2006. Some of these include:

- Meetings with the EPA via the EPA Support Branch of DEC.
- Annual Minerals Sands Agreement Rehabilitation Coordination Committee – a group made up of representatives from the Department of Environment and Conservation (DEC), Department of Mining and Petroleum (DMP), Department of Water and Department of Agriculture Western Australia who administer the performance of rehabilitation and wider environmental management within the Minerals Sands (Cooljarloo) Mining and Processing State Agreement Act 1988 tenement.
- Meetings with the Shire of Irwin.
- Tiwest display at Dongara Festival describing intentions regarding he Dongara project
- Meetings with DBNGP, Origin Energy and ArcEnergy (now AWE) to ensure mining activities remain outside pipe line corridors
- Discussions with Aboriginal groups (the Amangu Group)
- Review of the Environmental Scoping Document by OEPA and DEWHA

There were no issues raised by key stakeholders during consultation beyond those addressed in this document.

Potential stakeholders for the Dongara Project and planned consultation to support project approvals and implementation is tabulated in Table 13. An initial project briefing will be held for the relevant Western Australian government agencies (via the Mineral Sands Rehabilitation Coordination Committee) later in 2009. Following this, specific consultation with relevant Government agencies will be undertaken as determined in this briefing as guided by EPA Service Unit.

Table 13: Stakeholder Consultation Strategy

Stakeholder	Strategy
Government	
Department of Environment, Water, Heritage and the Arts and Office of Environmental Protection Authority	• Project to be assessed via a bilateral agreement between the Commonwealth and the Western Australian Government via a PER as per Part IV of EP Act 1999.
Department of Environment and Conservation	• Interagency briefing (MSARCC Group) • Direct consultation as guided by EPA • DEC EMB negotiate biodiversity offsets • Identify any secondary approvals required (Works Approvals, Permits to Take – post Part IV approval) and when
Department of Water	• Interagency briefing (MSARCC Group) • Specific consultation on application for groundwater abstraction allocation • Direct consultation as guided by EPA
Department of Mines and Petroleum	• Interagency briefing (MSARCC Group) • Direct consultation as guided by EPA • Develop and submit Mining Proposal concurrent with EPA assessment (late 2009) • Develop and submit Project Management Plan – Safety (2013)
Department of Planning and Infrastructure	• Consult regarding interactions with corridors for Dampier to Bunbury Natural Gas Pipeline, Parmelia Pipeline and other reserves.
Main Roads WA	• Consult regarding project and potential issues
Irwin Shire	• Continue routine activity/progress updates
Concurrent Land Users/Holders & Owners of adjoining property	
Neighbouring Landholders	• Negotiate land access agreement with owner of freehold title within M70/1195 • Discuss proposal with neighbours to identify and address concerns
Oil and Gas operators in the area (Origin Energy / AWE)	• Continue correspondence regarding plans for project to minimise conflict and exploit opportunities for mutual benefit
Western Power	• Avoid ray lines associated with microwave repeater station • Remain abreast of development in Pinjar to Cataby HV Transmission line duplication project
Dampier to Bunbury Natural Gas Pipeline & Parmelia Natural Gas Pipeline – Operators and Construction contractors (DBNG looping project)	• Activities outside pipe corridors (pref>100m) • Continue discussions regarding mining access and implications / standard for crossing pipeline with mining equipment
Apiarists & Wildflower Pickers	• Determine current site users and contact regarding activities to determine their interest and concerns – via DEC and association
Resource companies with tenements in the area (Hudson Resources & Iluka Resources)	• Continue to share environmental data and discuss opportunities for joint environmental programs (trials, surveys etc) • Examine business synergy opportunities (eg haulage of concentrate, lease/capital exchange etc)
Local Community	
Dongara/Denison Residents & Community Groups	• Respond to external enquiries promptly • Attend Dongara Festival (Nov – have attended since 2006) to provide an opportunity to inform and raise concerns regarding project
Amangu Group - Native Title Claimants	• Honour existing agreements and consult regarding ongoing development of the project • Consult regarding heritage protection site activities • Include in circulation list for draft PER
Non Government Organisations	
Wildflower Society WA, Conservation Council WA	• Consult regarding current and proposed activities to provide opportunity for input / comment – brief once scoping document finalised, include on circulation list for draft PER and keep updated regarding progress.

11. ENVIRONMENTAL IMPACTS AND MANAGEMENT SUMMARY TABLE

Table 14 Proposed management of Environmental Impacts, to be further addressed in the PER

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
BIOPHYSICAL					
Flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Clearing of ~900ha and Mulch Harvesting	Adverse impacts to conservation status of flora species (Threatened, DRF, Priority, locally restricted), Threatened Ecological Communities due to clearing, dust generated, mulching and introduction of weeds and dieback.	A Rehabilitation Plan will be developed including the controls below and others: - Control of clearing activities to minimise footprint and impact to significant species, and ensure availability of quality rehabilitation resources required. - The definition of a Rehabilitation objective (final landuse), for the unallocated Crown Land - The practices to be implemented during the project to maximise the quality of Rehabilitation outcomes in pursuit of that objective. - Specific rehabilitation strategies for the management and return of significant flora and fauna species and communities or identified recalcitrant species (where required). - Preliminary completion criteria for key aspects of rehabilitation based on completion criteria developed for Cooljarloo -A plan to manage the potential impacts associated with harvesting of mulch for rehabilitation will be developed.	The results and findings of local and regional flora and vegetation investigations will be presented in the PER. Information to be presented will include: - A compilation of previous studies and investigations on a local and regional scale - Floristic community mapping within project areas and surrounds - Regional scale vegetation assessment - A detailed impact assessment for all relevant species and communities from mining including cumulative environmental impacts. - Dieback status - Weed status - Rehabilitation procedures and techniques from Cooljarloo Mine Site will be reviewed, revised and adopted into the

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
				-Strategy for progressive rehabilitation A Weed and P. cinnamomi Hygiene Management Plan for the mining proposal including maps will be developed and presented in the PER.	Rehabilitation Management Plan in alignment with results and recommendations of studies for the PER.
Fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	- Clearing of ~900ha - Potential changes to fire regime - Changes to groundwater levels or quality - Installation of mining infrastructure	- Loss of habitat/fragmentation - Direct fauna injury/death - Increased abundance of introduced predators - Impacts to the status of conservation species - Changes to hydrology impacting on subterranean fauna	- Requirements for fauna habitat re-establishment will be incorporated into the Rehabilitation Plan. - A Fauna Monitoring Plan addressing ongoing monitoring requirements, as identified in impact assessment, to support impact mitigation measures and demonstrate recovery/rehabilitation of habitat. - Clearing will be minimised where possible - Potential impacts to subterranean fauna habitat associated with groundwater drawdown will be addressed in a Groundwater Management Plan.	Outcomes of desktop, reconnaissance and detailed targeted studies and surveys will be presented in the PER including: - Characterisation of the fauna assemblages and habitat types - identification of rare or otherwise poorly represented species (locally and regionally) - Assessment of the potential for loss of habitat to adversely impact conservation status - Impact assessment upon fauna (including Stygofauna)
Wetlands (wetlands, rivers)	To maintain the integrity, ecological functions and environmental values of wetlands	- Mine dewatering and Abstraction for Mine Water Supply - Clearing, intersection or excavation near a wetland	- Loss of significant wetland areas from clearing or groundwater drawdown - Reduced distribution of flora and fauna associated with wetlands	A Surface and Groundwater Management Plan will be developed addressing impact mitigation and monitoring strategies required for wetland management.	Modelling the Yarragadee and Superficial formations in the project area to determine aquifer yield, likely drawdown potential and adverse impacts on wetlands. Map and characterise wetland areas and dependencies with respect to surface and

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
					subsurface hydrology
Water (surface or ground)	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.	Abstraction for mining activities and water supply	- Over-abstraction resulting in impacts to vegetation, fauna and neighbouring users - alteration of surface and sub surface flows	A Surface and Groundwater Management Plan will be developed addressing impact mitigation and monitoring strategies for native vegetation and fauna management as required.	Modelling of the Yarragadee and Superficial formations in the project area to determine level and extent of potential groundwater drawdown. The modelling results will be used to assess potential adverse impacts on vegetation and fauna.
Land (terrestrial/ landform)	To maintain the integrity, ecological functions and environmental values of the soil and landform.	- Clearing of ~900ha - Pit excavation	- Unsuitable landform and soil profile re-construction post mining	A Material Identification and Management Plan will be developed as a component of the Rehabilitation Plan. The plan will identify materials suitable for subsoil and those requiring treatment or burial deeper in the soil profile.	Detailed soil and landform mapping
Land (marine)	To maintain the integrity, ecological functions and environmental values of the seabed and coast.	N/A	N/A	N/A	N/A
Conservation Areas	To protect the environmental values of areas identified as having significant environmental attributes.	Dewatering the superficial aquifer for mining activities	Groundwater drawdown impacting on Yardanogo Nature Reserve	A Surface and Groundwater Management Plan will be developed addressing impact mitigation and monitoring strategies for native vegetation and fauna management as required.	Assessment of the impact on vegetation from groundwater drawdown

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
POLLUTION MANAGEMENT					
Air Quality	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards	Operation of fleet vehicles and diesel pumps	- impact of dust emission on adjacent sensitive receptors eg. Neighbours such as landholders, vegetation, rehabilitation or Beharra Springs Natural gas facility - diesel combustion contributing to carbon pollution	- Develop Dust Management Plan. - Develop Greenhouse Gas Emissions Inventory and Management Plan to monitor, report and reduce carbon pollution in line with the EPA Guidance Statement No. 12 – Minimising Greenhouse Gas Emissions, EPA 2002, National Greenhouse and Energy Reporting Act 2007, Energy Efficiency Opportunities Act 2006 and other Acts and guidelines as relevant	Assessment of the risks associated with dust generated during mining activities will involve: - Examination of the project location in relation to sensitive receptors (i.e. residences) and prevailing wind directions/speeds to assess the risk of dust impacts to these occurring - Proposed effective dust control measures to be implemented and methods to monitor mitigation success.
Water Quality (surface, marine or ground)	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards	- Abstraction for mining activities and water supply - clearing - road construction - hydrocarbon and chemical transfer and storage	- alteration of water quality due to mining (acidification from potentially acid forming soils) or abstraction - contamination of groundwater from uncontrolled sewerage discharge - hydrocarbon contamination of groundwater from poor transfer practices and incorrect bunding	A Material Identification and Management Plan will be developed as a component of the Rehabilitation Plan based on the results from the acidic soil studies. The plan will identify materials suitable for subsoil and those requiring treatment or burial deeper in the soil profile. A Waste Management Plan will be prepared to identify and manage all non-processing waste streams.	Acidic soils investigations will involve: - drilling at locations within and outside the proposed areas of mining - sampling across the soils profile at one metre intervals to a depth exceeding the proposed mining and modelled groundwater drawdown by at least two meters - analysing samples for change in pH under rapid oxidation. - analysing representative samples from each lithological unit within each drilling location

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
					via the SPOCAS technique to determine the acid forming potential. - Samples identified by the pH change under rapid oxidation as potentially high risk will be selected as representative of the relevant lithological unit for SPOCAS testing. All results from acidic soil investigations will be submitted in the PER.
Soil Quality	To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use, and consistent with appropriate criteria	- top soil and overburden removal and mining - sewerage storage - hydrocarbon and chemical transfer and storage	- Potential to encounter pyritic acid formation during mining or dewatering activities	A Material Identification and Management Plan will be developed as a component of the Rehabilitation Plan based on the results from the acidic soil studies. The plan will identify materials suitable for subsoil and those requiring treatment or burial deeper in the soil profile. An Acid Sulphate Soil Management Plan will be developed if deemed necessary by results of the Acidic Soil Investigation. From the review of previous soil studies, gaps in knowledge in relation to soils and soil landscapes at Dongara will be identified for management of soils post mining. A comprehensive data set will be formed for strategic planning, operational management, and rehabilitation design.	The review of previous soils studies will identify and list the key issues for: - landform reconstruction; - profile reconstruction; - rehabilitation; - soil-water relationships; - soil-vegetation relationships; - landform-soil-wetland interaction; and - wetland hydrology-subsurface water flow. Acidic Soil Investigation as specified in Section 6.5.2

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
Noise	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.	Operation of the plant, machinery and haulage fleet	Adverse impacts on neighbour amenity	Noise emissions from the project are not expected to impact on nearby residents, will not create nuisance beyond the boundary and will comply with Environmental Protection (Noise) Regulations 1997.	N/A
Radiation	To ensure that radiological impacts to the public and the environment are kept as low as reasonably achievable and comply with acceptable standards.	Concentration of mineral containing higher percentages	Increase exposure of community and general environment to radioactive materials excavated during mining	A Radiation Management Plan (RMP) will be developed for the Dongara project area and managed in the same manner as Tiwest's Cooljarloo Mine Site. Key objectives included in the RMP will be: - to restore the surface of the mined area to the pre-operational radiation conditions. - To conduct an operational radiation monitoring programme covering the areas of a radionuclide dust and water monitoring, personal gamma monitoring and area gamma radiation monitoring.	Examination of the Dongara ores against exposure standards.
Light	To avoid or manage potential impacts from light overspill and comply with acceptable standards.	Mining operations at night time	Disturbance to fauna behaviour	Minimise use of lighting where practical without compromising safety.	Nil

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
Greenhouse gases	To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions.	- diesel consumption from mining contractor and pumps - indirect consumption from gas/electricity suppliers	- increasing greenhouse gas emissions - increased scrutiny from regulators and public	- Develop greenhouse gas emissions inventory for the project. - Emissions profile for the project will be characterised and improvement opportunities identified. These will be incorporated in business improvement systems.	Nil
SOCIAL SURROUNDS					
Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	clearing and disturbance to 800ha+	- impeded access to areas of aboriginal significance resulting in loss of connectivity to land - damage to areas of cultural significance	Consultation with the relevant Native Title Claimants, the Amangu Group via the Yamatji Barna Baba Maaja Aboriginal Corporation, was resolved by agreement WAD6002/04. Implement agreed procedure for preservation of heritage: - pre-disturbance survey - use of heritage observers during clearing - stop work on identification of heritage issues	No, refer to Section 6.6
Visual Amenity	To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.	construction of operations and entry to the site	- Poor site rehabilitation	Progressive rehabilitation will be conducted through out the life of mine according to the Rehabilitation Plan.	Nil
Recreation	To ensure that existing and planned recreational uses are not compromised.	N/A	N/A	N/A	N/A

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
Risk	To ensure that risk from the proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.	Operating machinery adjacent to and within uncleared heath and woodlands.	- Increased risk of bush fire that could impact on flora species and communities and habitat for fauna species of the area.	Consultation with the DEC to develop a Fire Management Plan that will be submitted with the PER. This will consider the objectives of fire management (e.g. preservation of biodiversity, property and personnel), strategies to achieve these and monitoring to demonstrate success or otherwise.	Nil
Vehicular Movements	To minimise impacts associated with constructing and operating road infrastructure	Traffic associated with mining activities	Increased dust generation impacting on neighbours and adjacent vegetation. Increased use of Brand Hwy and access road	A Dust Management Plan will be developed to minimise dust generated.	Nil
OTHER					
Decommissioning	To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.	Rehabilitation decommissioning and removal of plant	Site rehabilitation not meeting completion criteria, loss of biodiversity and state liability	Progressive rehabilitation will be conducted through out the life of mine as per the Rehabilitation Plan that will be developed. Development of completion criteria in consultation with key stakeholders	Directives and interpretations from all Environmental studies will be used to identify potential environmental impacts, key constraints and requirements for rehabilitation. Rehabilitation procedures and techniques from Cooljarloo Mine Site will be reviewed, revised and adopted according to the results of studies for the PER. Completion Criteria will be developed to demonstrate that the reconstructed landforms provide the foundation for achieving Tiwest's rehabilitation objectives, taking into account any major limitations for

Factor	Objective	Proposed Activity	Potential Impacts	Potential Management	Additional Studies
					rehabilitation and the environmental significance of the area.

Table 15: Consideration of Principles of Environmental Protection (EPA, 2004)

Principle	Relevant Yes/No	If yes, consideration
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by – (a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and (b) an assessment of the risk – weighted consequences of various options.	Yes	Potential environmental impacts of the project were identified in consultation with key stakeholders (Table 11). Current information has been reviewed for all potential environmental impacts. To address gaps identified in knowledge, studies/investigations are planned to increase the information available, enabling a comprehensive impact assessment to be completed (Table 14). An impact assessment based on the directives and results of environmental studies and investigations will be conducted and management options proposed to minimise impact. The PER will contain results of the environmental investigations, studies, the impact assessment and an assessment of overall risk to the environment.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations	Yes	A greenhouse gas emissions inventory and management plan will be developed to monitor, report and reduce carbon pollution in line with the EPA Guidance Statement No. 12 – Minimising Greenhouse Gas Emissions, EPA 2002, National Greenhouse and Energy Reporting Act 2007, Energy Efficiency Opportunities Act 2006 and other Acts and

		guidelines as relevant. Environmental Impact Assessment will assess potential for project to result in loss of environmental values of today and future generations. There are inherent within assessment of flora, fauna and other ecological components plus less significant aspects and risks such as greenhouse emissions.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Yes	In accordance with relevant EPA Guidance Statements, investigations listed in Table 14 will be conducted to provide sufficient information to address potential environmental impacts. Impacts will be minimised through proposed management detailed in Table 14, principally through development of the Rehabilitation Plan.
4. Principles relating to improved valuation, pricing and incentive mechanisms (1) Environmental factors should be included in the valuation of assets and services. (2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement. (3) The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. (4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.	No	
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Yes	The Dongara project area will be subject to Tiwest's Corporate Standards and overarching objective to ensure waste (including hazardous wastes) is efficiently managed to ensure eco-efficiency, legal compliance, pollution prevention, expectations of the community and a high standard of site aesthetics.

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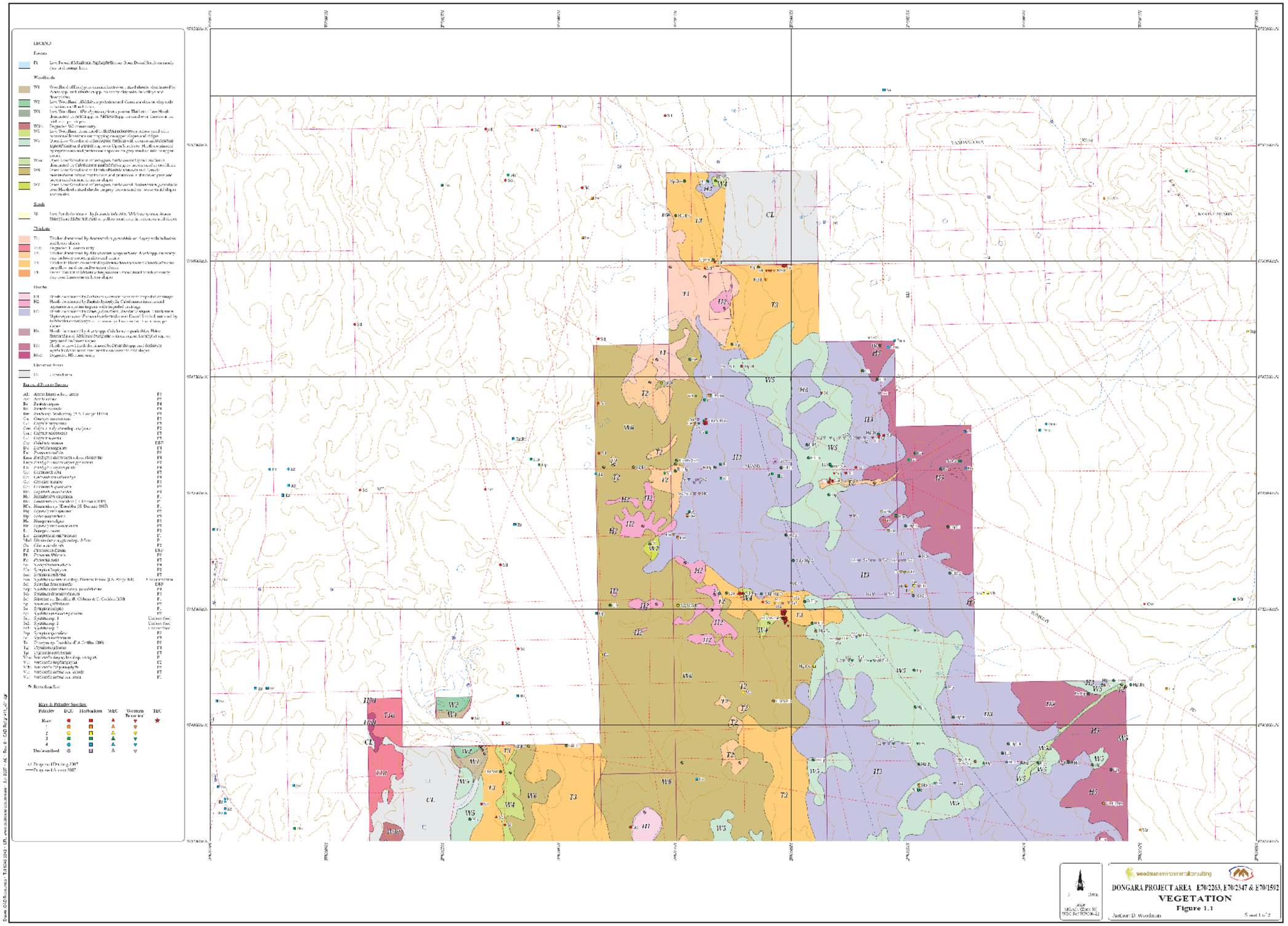
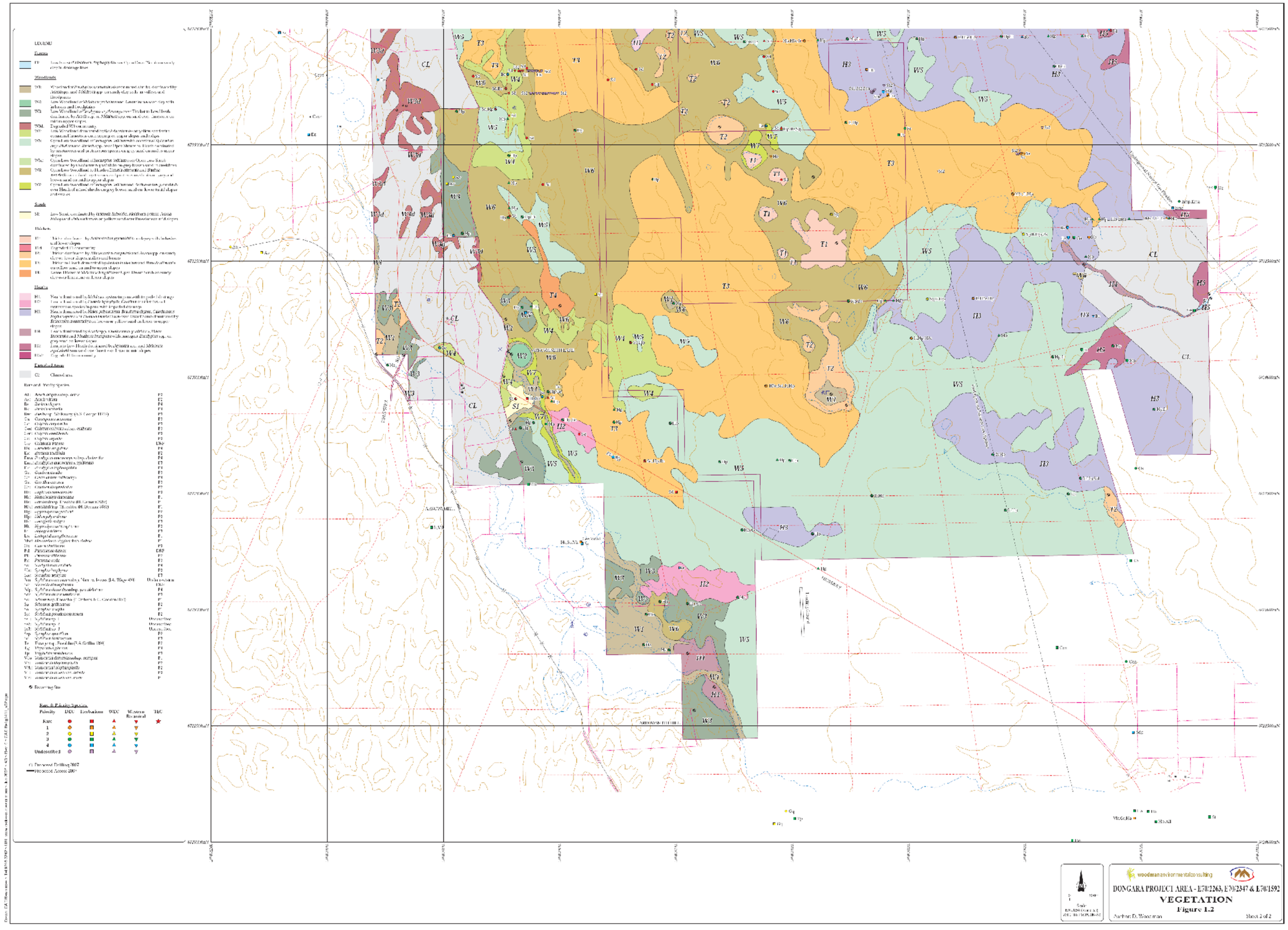
13. APPENDICES

Appendix A:

Detailed structural mapping of vegetation communities over the region bounded by Exploration Licences E70/1592, E70/2263, E70/2347 and E70/2430.


LEGEND
Forests
Woodlands
Sands
Thickets
Heaths
Disturbed Areas
Rare & Priority Species
DONGARA PROJECT AREA E70/2263, E70/2347 & E70/1592
VEGETATION
Figure 1.1
woodman environmental consulting


LEGEND
Rare & Priority Species
Priority
DEC
Locations
WEC
Western Botanical
TEC
Rare
1
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Undescribed
Proposed Drilling 2007
Proposed Access 2007
woodmanenvironmentalconsulting
DONGARA PROJECT AREA - L70/2263, L70/2347 & L70/1592
VEGETATION
Figure 1.2
Author: D. Woodman
Sheet 2 of 2

Appendix B:

Woodman Environmental Consulting

Tiwest Pty Ltd. Dongara Tenements Flora, Vegetation & Phytophthora Cinnamomi Assessment; June 2007.

TIWEST PTY LTD

DONGARA TENEMENTS

FLORA, VEGETATION AND PHYTOPHTHORA CINNAMOMI ASSESSMENT

June 2007

woodmanenvironmentalconsulting

A.C.N. 088 055 903

DOCUMENT REVISION HISTORY

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A	Released to the client for review	BT	GW	24-04-07
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0	Final	BT	Nick Sibbel	12-06-07

Reference: Tiwest 06-23

DISCLAIMER

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EXECUTIVE SUMMARY

Tiwest Joint Venture commissioned Woodman Environmental Consulting Pty Ltd to conduct detailed flora, vegetation and Dieback *Phytophthora cinnamomi* studies of the Dongara tenements, primarily to assess potential impacts from a proposed exploration drill program and to provide information to mitigate impacts. This work was also conducted as part of future planning for mine development.

Experienced botanists carried out the structural plant community mapping in October, November and December 2006. The dieback interpretation was conducted by an accredited dieback interpreter during November 2006.

A total of 376 vascular plant taxa belonging to 59 plant families were recorded within the Dongara tenements during the survey in spring 2006. Two Declared Rare Flora (DRF) were recorded within the project area, *Paracaleana dixonii* and *Stawellia dimorphantha*. One individual of *Paracaleana dixonii* was located in the eastern section of the project area in community H5 which is characteristically a lateritic heath. *Stawellia dimorphantha* was recorded at 25 locations in a number of vegetation community types including W3, W4, W5, W6, H3, S1, T2 and T3. A total of 19 Priority species were recorded in the project area during spring 2006 in addition to 2 undescribed *Stylidium* species related to the *Stylidium piliferum* complex.

A total of 16 introduced (weed) taxa were recorded within the project area, none of which are defined by the Department of Agriculture and Food as Declared Weed Species.

19 structural plant communities were described and mapped within the project area including:

Forests

F1: Low Forest *of Melaleuca rhaphiophylla* over Open Dwarf Scrub on sandy clay in drainage lines.

Woodlands

W1: Woodland of *Eucalyptus camaldulensis* over mixed shrubs dominated by *Acacia* spp. and *Melaleuca* spp. on sandy clay soils in valleys and floodplains.

W2: Low Woodland of *Melaleuca preissiana* and *Casuarina obesa* on clay soils in basins and floodplains.

W3: Low Woodland of *Eucalyptus erythrocorys* over Thicket to Low Heath dominated by *Acacia* spp. or *Melaleuca* spp. on sand over limestone on mid to upper slopes.

W4: Low Woodland dominated by *Banksia prionotes* on yellow sand with occasional limestone outcropping on upper slopes and ridges.

W5: Open Low Woodland of *Eucalyptus todtiana* with occasional *Xylomelum angustifolium* and *Banksia* spp. over Open Shrubs to Heath dominated by myrtaceous and proteaceous species on grey sand on mid to upper slopes.

W5a: Open Low Woodland of *Eucalyptus todtiana* over Open Low Scrub dominated by *Calothamnus quadrifidus* on grey brown sand in creeklines.

W6: Open Low Woodland to Heath of *Banksia attenuata* and *Banksia menziesii* over mixed myrtaceous and proteaceous shrubs on grey and brown sand on mid to upper slopes.

W7: Open Low Woodland of *Eucalyptus todtiana* and *Actinostrobus pyramidalis* over Heath of mixed shrubs on grey brown sand on lower to mid slopes and swales.

Scrub

S1: Low Scrub dominated by *Jacksonia hakeoides*, *Melaleuca systena*, *Acacia blakelyi* and *Hakea trifurcata* on yellow sand over limestone on mid slopes.

Thickets

T1: Thicket dominated by *Actinostrobus pyramidalis* on clayey soils in basins and lower slopes.

T2: Thicket dominated by *Allocasuarina campestris* and *Acacia* spp. on sandy clay on lower slopes, gullies and basins.

T3: Thicket to Heath dominated by *Banksia hookeriana* and *Banksia attenuata* on yellow sand on mid to upper slopes.

T4: Dense Thicket of *Melaleuca huegelii* over Open Dwarf Scrub on sandy clay over limestone on lower slopes.

Heaths

H1: Heath dominated by *Melaleuca systena* in pans with impeded drainage

H2: Heath dominated by *Banksia leptophylla*, *Calothamnus hirsutus* and myrtaceous species in pans with impeded drainage

H3: Heath dominated by *Hakea polyanthema*, *Beaufortia elegens*, *Calothamnus blepharospermus* or *Eremaea beaufortioides* over Dwarf Scrub dominated by *Ecdeiocolea monostachya* on brown or yellow sand on lower to upper slopes.

H4: Heath dominated by *Acacia* spp. *Calothamnus quadrifidus*, *Hakea lissocarpha* and *Melaleuca leuropoma* with emergent *Eucalyptus* spp. on grey sand on lower slopes.

H5: Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes.

The condition of the vegetation within the Dongara tenements was recorded as Pristine to Excellent. The majority of sites surveyed recorded minimal signs of disturbance. However, the project area has been impacted by 3D Seismic Surveys conducted by Origin Energy in

1998 and 2001. Longitudinal source and latitudinal receiver lines currently closed for rehabilitation purposes are visible throughout the project area. There has been minor clearing for pipeline corridors and the Beharra Springs Gas Plant is central to the project area. In addition, areas near the eastern, western and northern boundaries of the project have been partially cleared and are adjacent to farming properties. The Yardanogo Nature Reserve is located near the north western border of the project area.

No *Phytophthora cinnamomi* infestations were located during the assessment. However, a small part of the project area was determined to be unmappable for dieback interpretation due to the recent burn in adjacent vegetation. Coincidently, the unmappable areas were determined to be at the greatest risk of dieback infestation. These areas include the public, gravelled Mt Adams Road and the access road to the gas plant (Appendix F).

The exploration drilling for the Tiwest Dongara project has the potential to adversely impact flora and vegetation. These impacts are:

1. Disturbance of plant communities – Full clearing of vegetation will not be required along the proposed exploration drill lines as drill rigs and associated vehicles drive over existing low vegetation and avoid trees. Occasionally a rubber tyred loader will be used to flatten vegetation for vehicle access where it is too high or thick for light vehicles and drill rigs to drive over. Future mine development would require full clearing of plant communities.

2. Loss of significant flora species – There are a number of Declared Rare and Priority Flora species and undescribed taxa that are potentially located within areas to be cleared.

3. Risk of fire –Vehicle movement and machinery operation has the potential to cause fires in the densely vegetated areas.

4. Negative impacts to Conservation values of Nature Reserves – Parts of the project area border the Yardanogo Nature Reserve and the introduction of weeds or plant diseases, or ignition of a wildfire during drilling activities could impact the value of the Nature Reserve.

5. Potential introduction and spread of weeds and plant diseases such as *P. cinnamomi* by ground disturbance activities and vehicle traffic.

6. Indirect impacts – Ground disturbance activities and vehicle traffic may lead to the generation of dust and impacts to surface drainage patterns.

The following recommendations are made based on the results of the flora, vegetation and dieback survey and are relevant for future works within the Dongara project area:

1. Further definition of the local and regional extent of DRF species *Paracaleana dixonii,* and *Caladenia wanosa,* in addition to 1 poorly known and 3 undescribed *Stylidium* species will be required.

2. The regional conservation significance of plant communities to be impacted by the proposed mining operations requires further investigation to confirm the representation of plant communities in the conservation estate.
3. The Dongara leases should be fenced from public access prior to commencement of mine development to ensure hygiene precautions are uniform across the site and the potential for third parties to introduce *P. cinnamomi* is reduced.
4. Weed and *P. cinnamomi* hygiene measures should be implemented for the drilling program followed by the development of an integrated hygiene management plan for any future mining operations.
5. Further investigations of the potential impacts of mining on surface and subsurface hydrology and associated impacts on flora and vegetation are required.

1 INTRODUCTION

Tiwest Joint Venture (Tiwest) operates the Cooljarloo Mineral Sands Mine located approximately 160km north of Perth, Western Australia. Operations currently involve dry mining in shallow ore bodies north of Mullering Farm. In addition, Tiwest own a number of exploration leases including the Dongara tenements E70/1592, E70/2263, E70/2430 and E70/2347 located approximately 20km south east of Dongara. The Dongara tenements are located on Unallocated Crown Land and private property. Parts of the project area have been previously impacted by 3D Seismic Survey Programs conducted by Origin Energy during 1998 and 2001. There has been minor clearing for pipeline corridors and the Beharra Springs Gas Plant is central to the project area. In addition, areas near the eastern, western and northern boundaries of the project have been partially cleared and are adjacent to farming properties. The Yardanogo Nature Reserve is located near the north western border of the project area.

Tiwest are currently undertaking exploration drilling programs on the Dongara tenements to define mineral sand resources. Exploration drilling approvals under the *Mining Act 1978* and *Environmental Protection Act 1986* require impacts to flora and vegetation to be described and appropriate management practices to mitigate impacts to be identified.

Initial drilling programs conducted on the leases were supported by detailed searching of proposed drill lines for significant flora species. These searches were conducted by Western Botanical during 2005 and 2006 (Western Botanical 2005a,b and 2006).

Tiwest commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct detailed flora, vegetation and Dieback *Phytophthora cinnamomi* studies of the Dongara tenements to identify potential impacts of a proposed exploration drilling program and provide management measures to mitigate impacts. In addition, these studies are to form the basis for ongoing characterisation of the receiving environment to facilitate approvals for future sand mining.

2 AIMS

The aim of this project was to obtain information on the plant communities, flora species and *P. cinnamomi* distribution in all remnant native vegetation within the Dongara tenements. Information collected during these surveys will facilitate management of flora, vegetation and *P. cinnamomi* hygiene for future proposed exploration and subsequent mining.

The tasks required to meet this aim were:

Vegetation

1. Review and collate existing data on soil and vegetation within the survey area.
2. Map the plant communities within the survey area from aerial photography followed by ground confirmation.
3. Collect quantitative data from sites located within each community.
4. Review the conservation status of each plant community and its sensitivity to disturbance.
5. Record the condition of the vegetation.

6. Provide recommendations to minimise impact on sensitive vegetation, manage weed hygiene and rehabilitation.

Flora

1. Review and collate existing data on Rare and Priority Flora in the survey area.
2. Search for Rare and Priority Flora species within the survey area.
3. Produce a list of the vascular plant species recorded within each community, based on site data as well as opportunistic collecting.

***Phytophthora cinnamomi* (Dieback)**

1. Survey for and map the presence of *Phytophthora cinnamomi* (Dieback) within the project area, with mapping to include uninterpretable areas.
2. Provide recommendations to manage *P. cinnamomi* issues.

3 EXISTING ENVIRONMENT

3.1 Regional Soils and Landforms

The Dongara tenements are located within the Geraldton Sandplains (GS) Biogeographical Region (Environment Australia, 2000). The Geraldton Sandplains bioregion is situated on the 'sandy earths of an extensive, undulating, lateritic sandplain mantling Permian to Cretaceous strata' (Desmond and Chant 2001). The Lesueur Sandplain (GS3) which is a subregion within the Geraldton Sandplains more specifically comprises 'coastal Aeolian and limestones, Jurassic siltstones and sandstones (often heavily laterised) of the central Perth Basin' (Desmond and Chant 2001).

The survey area is located within the Perth Basin geological province, which extends from the Murchison River to the south coast, and eastwards to the Darling fault. Over 90% of the Perth Basin is covered by Pleistocene and Holocene sedimentary deposits, with the only exposures of pre-Quaternary (younger than 2 Ma) rocks located in the Hill River/Mount Lesueur region. Mesozoic (225 – 65 Ma) sedimentary units are the major sources for groundwater and hydrocarbons in the Basin (The Department of Planning and Urban Development (DPUD) 1994).

The Dongara area was broadly mapped and described by Beard (1976) at a scale of 1:250,000. Within the Dongara survey region, Beard describes the vegetation, soils and landforms of 11 systems, 3 of which overlap the project area; the Illyarrie, Eridoon and Tathra Systems.

The Illyarrie System is a coastal limestone belt up to 15km wide with undulating hilly country of lithified calcarenite overlain by yellow siliceous sands (Beard 1976). In parts, the sand depth is minimal and the limestone rock is exposed. East of the coastal limestone belt is a flat coastal plain, the Eridoon System. Small rivers and creeks have transported sand onto the plain and formed longitudinal ridges in parts where the sand has been blown. The sands are bleached, turning yellow at depth with clay-loams approximately 1m below the surface. There are some small lakes and swamps in depressions and limited occurrences of heavier soils on alluvial flats. East of the Eridoon System is the Tathra System where outcrops of laterite on ridges and breakaway are a feature.

3.2 Regional Flora and Vegetation

The project area is located within the Irwin Botanical District (Northern Sandplains Region), within the Southwest Botanical Province as defined by Beard (1990). Dominant plant families within the Irwin Botanical District include Proteaceae (*Grevillea, Banksia*), Myrtaceae (*Eucalyptus, Melaleuca*), Mimosaceae (*Acacia*), Casuarinaceae (*Casuarina, Allocasuarina*), Asteraceae (daisies), Chenopodiaceae (salt bushes) and Poaceae (grasses). Vegetation systems within the region were broadly mapped and described by Beard at a scale of 1:250,000 (Beard 1976).

The western margin of the project area intersects the coastal limestone belt characteristic of the Illyarrie System and is dominated by woodlands of *Eucalyptus erythrocorys* up to 10m over 'an open shrub understorey containing *Acacia blakelyi*, *A. pulchella*, *A. spathulata*, *Dryandra sessilis*, *Hakea costata*, *Hibbertia hypericoides*, *Hibiscus huegelii*, *Hybanthus calycinus*, *Scholtzia* sp. and Restionaceae' (Beard 1976). North of the Arrowsmith River the vegetation is predominantly thickets of *Acacia*, *Melaleuca* and mallee.

The Eridoon System is characterised by a sandplain community of 'scattered small trees up to 5m tall, an open layer of tall shrubs of 1-3m and a closed layer of small heath-like shrubs <1m'(Beard 1976). On the sandhills the tree layer diminishes. In low lying, winter wet areas the heath is approximately 30cm tall with scattered *Xanthorrhoea*, with *Calytrix strigosa*, *Eremaea pauciflora*, *Grevillea eriostachya*, *Melaleuca scabra*, *Petrophile media* and Restionaceae. In wetter areas, *Melaleuca thyoides*, *M. lanceolata* and *M. rhaphiophylla* are present.

The Tathra System consists of low, lateritic heaths and scrub heaths. Species present on lateritic heath include *Hakea auriculata, Dryandra fraseri*, *Melaleuca scabra*, *Allocasuarina humilis*, *Petrophile* sp., *Melaleuca radula* and Restionaceae (Beard 1976). *Eucalyptus macrocarpa* was recorded at the tops and foots of breakaways. The scrub heath is quite diverse and heterogeneous and generally consists of scattered shrubs to 2m over a dense layer of small shrubs <1m with occasional *Nuytsia floribunda*. Taller tree species *Eucalyptus todtiana*, *Banksia attenuata*, *B. menziesii* and *B. prionotes* are usually confined to valleys and deep sands.

These systems were further divided into vegetation community types (associations), related to physiognomy by Shepard *et al* (2000). There are 8 vegetation associations located within the Dongara project area (Table 1, Figure 2).

A search of The Department of Environment and Conservation (DEC) Threatened Ecological Community (TEC) database was conducted for the project area with an approximate 5km buffer for the following coordinates:

- NW; 29° 18' 03.93" 115° 00' 09.39"
- SE 29° 39' 57.39" 115° 17' 04.95"

There were no Threatened Ecological Communities (TEC's) recorded within the project boundary (DEC 2007d). However, occurrences of the TEC 'Assemblages of organic mound springs of the Three Springs area', considered to be 'Endangered', are located within 25km of the project area. In addition, the 'Vulnerable' TEC 'Ferricrete floristic community (Rocky Springs type) was recorded within 25km of the project area.

A search of the Department of Environment and Conservation's (DEC) Rare and Priority Flora Database (DEC 2007b) revealed that 5 Declared Rare Flora (DRF), *Eucalyptus leprophloia*, *Paracaleana dixonii*, *Stawellia dimorphantha*, *Caladenia wanosa* and *Thelymitra stellata* have been previously recorded within the search area in addition to a number of Priority Species (Table 2). A summary of results retrieved from the DEC regional database is provided in Appendix B. A definition of the Priority Flora categories as defined by the DEC (2007a) is given in Appendix A.

A search of the Department of Environment and Resources (DEWR 2007) databases revealed that there were no occurrences of wetlands of national or international importance within the search area. The south west of the project area supports an Australian Heritage Site 'Arrowsmith Lake Area, Brand Hwy, Dongara, WA'. This wetland is on the Register of the National Estate and includes an area of approximately 10,000ha surrounding the lower reaches of the Arrowsmith River, including Arrowsmith Lake and Arrowsmith Hill. This community supports unique flora and a range of waterfowl and land birds.

Table 1: **Description, Pre-european extent, Current Extent and Reservation Status of Vegetation Associations Related to Physiognomy in the Dongara Project Area (Shepard *et al*, 2000)**
Note: all values refer to hectares unless otherwise indicated

Vegetation Association	Description	Current Extent	Percentage of Pre-european Extent Remaining	Percentage held in IUCN Class Reserves	Reservation Priority*
352	Medium woodland; York Gum	113,255	15.2	3	L
377	Mosaic: Shrublands; scrub heath on limestone/ Sparse low woodland; illyarrie	72,491	99.4	74	L
378	Shrublands; scrub heath with scattered *Banksia* spp., *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats	68,049	62.0	21.1	M
379	Shrublands; scrub heath on the lateritic sandplains	128,007	20.2	20.3	M
392	Shrublands; *Melaleuca thyoides* thicket	1554	42.6	16.4	H
433	Mosaic: Shrublands; *Acacia rostellifera* and *Melaleuca cardiophylla* thicket/ Sparse low woodland; illyarrie	15,234	40.9	11.7	M
619	Medium woodland; River Gum (*Eucalyptus camaldulensis*)	114,211	99.9	0.2	N/A
748	Shrublands; *Melaleuca thyoides* thicket with scattered rivergum	312	79.7	48.9	M

*as defined by Desmond and Chant (2001), L= Low, M= Medium, H= High

Table 2: Declared Rare and **Priority Species Previously Recorded within the Dongara Search Area (DEC 2007b)**

Species	Conservation Code
Acacia latipes subsp. licina	P3
Acacia vittata	P2
Anthocercis intricata	P3
Baeckea sp. Walkaway (A.S. George 11249)	P3
Banksia elegans	P4
Banksia scabrella	P4
Caladenia wanosa	DRF
Calytrix chrysantha	P3
Calytrix ecalycata	P3
Calytrix eneabbenis	P3
Calytrix superba	P3
Dampiera tephrea	P2
Darwinia sanguinea	P4
Dryandra cypholoba	P3
Eremaea acutifolia	P2
Eucalyptus leprophloia	DRF
Eucalyptus macrocarpa subsp. *elachantha*	P4
Eucalyptus macrocarpa x *pyriformis*	P3
Eucalyptus zopherophloia	P4
Gastrolobium callistachys	P4
Guichenotia alba	P3
Georgeantha hexandra	P4
Grevillea erinacea	P3
Guichenotia quasicalva	P2
Hakea polyanthema	P3
Hemiandra sp. Eneabba (H. Demarz 3687)	P1
Hemigenia saligna	P3
Homalocalyx chapmanii	P1
Hopkinsia anoectocolea	P3
Hypocalymma gardneri	P2
Hypocalymma tetrapterum	P3
Isopogon tridens	P3
Lasiopetalum ogilveanum	P1
Mesomelaena stygia subsp. *deflexa*	P1
Micromyrtus rogeri	P1
Olax scalariformis	P3
Paracaleana dixonii	DRF
Persoonia filiformis	P2
Persoonia rudis	P3
Schoenus badius	P2
Schoenus sp. Eneabba (F. Obbens & C. Godden I154)	P1
Pityrodia viscida	P3

Species	Conservation Code
Stachystemon axillaris	P4
Stawellia dimorphantha	DRF
Stylidium diuroides subsp. paucifoliatum	P4
Stylidium drummondianum	P3
Stylidium pseudocaespitosum	P2
Stylidium torticarpum	P3
Synaphea aephynsa	P3
Synaphea oulopha	P1
Synaphea sparsiflora	P2
Thelymitra stellata	DRF
Thryptomene sp. Mingenew (Diels & Pritzel 332)	P3
Thysanotus glaucous	P4
Tricoryne sp. Eneabba (E.A. Griffin 1200)	P2
Tricoryne sp. Wongan Hills (B.H. Smith 794)	P2
Triglochin protuberans	P3
Verticordia blepharophylla	P2
Verticordia luteola var. *luteola*	P3
Verticordia luteola var. *rosea*	P1

3.3 Previous Studies

A number of surveys within the Northern Sandplains region have been undertaken in recent years, including several by J. S. Beard (1979; 1981 and 1990), Burbidge and Boscacci (1989); Griffin and Keighery (1989), Griffin (1998), *ecologia* Environmental Consultants (1995) and Halpern Glick and Maunsell (2000).

Woodman Environmental Consulting (2005) conducted vegetation mapping for ARC Energy's 3D seismic survey during spring 2004. The project encompassed an area of approximately 39,400ha, including 18,045ha of cleared land, 11,455ha of nature reserves (Yardanogo, Beekeepers and Dongara N.R) and areas of remnant native vegetation on private property and Vacant Crown Land totaling 9,900ha. A total of 515 vascular plant taxa belonging to 81 plant families were recorded in the survey area during spring 2004. The dominant families recorded were Myrtaceae, Proteaceae, Asteraceae and Cyperaceae. One DRF species, *Stawellia dimorphantha*, was recorded within the Yardanogo Nature Reserve during the survey in addition to 8 Priority species. These were *Anthocercis intricata* (P3), *Baeckea* sp. Walkaway (A.S. George 11249) (P3), *Banksia elegans* (P4), *Dampiera tephrea* (P2), *Eucalyptus zopherophloia* (P4), *Hakea polyanthema* (P3), *Hemigenia saligna* (P3) and *Schoenus* sp. Eneabba (F.Obbens & C.Godden I154).

In 2005 and 2006 Western Botanical conducted a target search for significant species along proposed drill lines within the Dongara project area (Western Botanical 2005a,b, 2006). One DRF, 19 Priority species and 3 potentially new (undescribed) species were located during the survey (Table 3).

Table 3: Significant Flora Recorded in the Dongara Project Area by Western Botanical during Spring 2005 and 2006 (2005a,b, 2006)

Species	Conservation Code
Banksia elegans	P4
Banksia scabrella	P4
Calytrix chyrsantha	P3
Guichenotia alba	P3
Hakea polyanthema	P3
Hemiandra sp. Eneabba (H. Demarz 3687)	P1
Isopogon tridens	P3
Mesomelaena stygia subsp. *deflexa*	P1
Olax scalariformis	P3
Persoonia filiformis	P2
Persoonia rudis	P3
Schoenus sp. Eneabba (F. Obbens & C. Godden I154)	P1
Stachystemon axillaris	P4
Stawellia dimorphantha	DRF
Stylidium carnosum subsp. Narrow leaves (J.A. Wege 490)	P1 or P2*
Stylidium diuroides subsp. *paucifoliatum*	P4
Stylidium sp.1	undescribed
Stylidium sp.2	undescribed
Stylidium sp.3	undescribed
Synaphea ?*aephynsa*	P3
Tricoryne sp. Eneabba (E.A. Griffen 1200)	P2
Verticordia ?*blepharophylla*	P2
Verticordia luteola var. *luteola*	P3

*yet to be listed on florabase

3.4 *Phytophthora cinnamomi*

There are four species of *Phytophthora* that are regularly identified in natural ecosystems in the south-west of Western Australia including; *P. cinnamomi*, *P. citricola*, *P. megasperma* and *P. drechsleri*. Of these species, only *P. cinnamomi* has been shown to cause disease epidemics in natural ecosystems, with the remainder behaving like native pathogens and causing little harm to vegetation. *P. megasperma* and *P. citricola* have the potential to cause localised disease outbreaks where site conditions have been modified to favour their survival and pathogenicity (Podger *et al*. 1996).

Phytophthora cinnamomi is a virulent plant pathogen that belongs to the water moulds and as such requires moist conditions to propagate, spread and infect hosts. This pathogen causes disease epidemics within native vegetation of the medium to high rainfall (annual rainfall >400mm) areas of South-western Western Australia, particularly in the plant families Proteaceae (*Banksias, Grevillea*s etc), Epacridaceae (Heaths), Myrtaceae (Eucalypts, *Calothamnus* etc) and Xanthorrhoeaceae (Grass trees) (Shearer and Tippett, 1989; CALM 2003; Podger *et al*. 1996). These plant families dominate the plant communities between Perth and Eneabba and include most of the rare and threatened plant species present in the

region. The destruction of many species susceptible to *P. cinnamomi* has had a serious impact on ecosystems in the south-west of Western Australia. The Proteaceae are most under threat from this pathogen with more than 86% of the species of Proteaceae assessed found to be susceptible to *P. cinnamomi* and various canker fungi (Wills and Keighery 1994). Studies have shown that the ecological changes brought about by *P. cinnamomi* infestation in terms of species loss and habitat structure modification are associated with low species diversity and abundance of faunal populations, particularly mammals (Wilson *et al*. 1994).

The pathogen can spread unaided by root to root contact, by native and introduced animal activity, along water drainage systems, and most commonly by human vectors in soil on machinery and footwear (CALM 2003).

Management of this pathogen in Western Australia is currently enforced under legislation according to land tenure. The *Conservation and Land Management Act 1984,* dictates hygiene requirements on Department of Conservation and Land Management (now Department of Environment and Conservation) managed lands, however there is no governing legislation for private property other than the *Environmental Protection Act 1986* which applies primarily to new proposals.

4 METHODS

4.1 Vegetation Mapping

Aerial photography of the project area was initially interpreted at a scale of 1:10,000 for structural plant community boundaries. Experienced botanists carried out the vegetation mapping during the months of October, November and December 2006 to ground truth the aerial interpretation.

All areas surveyed were traversed by vehicle and on foot to map vegetation boundaries. Detailed site recordings were taken at each community boundary change and regularly within communities. At each site a standard recording sheet was used to ensure the consistent collection of flora and site data. At each site the following information was collected within a 20m radius:

- Site location (including GPS co-ordinates, GDA Zone 50);
- Surface soil type, colour and presence of outcropping;
- Position of site in the local landscape;
- Site condition, including fire history and presence of any disturbance (as defined by Bush Forever (Government of Western Australia 2000);
- Height and cover of any tree species present;
- Height and cover of dominant vascular understorey plant species present;
- Presence of any other vascular plant species; and
- Vegetation structure (as defined by Muir (1977)).

An adaptation of the Muir (1977) classification of vegetation structure was used to describe the plant communities, as this has been used for the majority of historical vegetation studies in the region. This adaption utilises the vegetation classification system described in Table 1 in Muir (1977) and omits the use of floristic and soil codes which have been replaced by full Genus and Species labels in addition to descriptions of surface soils.

Where possible, the conservation status of each plant community was determined by referring to available regional studies in addition to comparisons with the Threatened Ecological Community (TEC) database provided by the Department of Environment and Conservation (2007d).

Plant species nomenclature used in this report follows that used by Packowska *et al*. (2000). All names were checked using the Max Database to ensure they are current. The conservation status of all species collected was checked using the current Department of Environment and Conservation list (DEC 2007c). Introduced (weed) species were recorded if they occured within a site or dominated a plant community.

4.2 *Significant Flora*

Previous background research and fieldwork conducted by Western Botanical (2005a,b, 2006) within the Dongara exploration leases provided a list of Rare, Priority Flora and significant species known to occur in the area. Limited targeted searches for these species were conducted during the vegetation mapping by Woodman Environmental Consulting in 2006. Unknown species encountered were collected for identification at the West Australian Herbarium by experienced taxonomists.

The locations of DRF and Priority species were recorded within detailed recording sites if they occurred in the immediate vicinity of that site. In areas outside of recording sites, usually in areas between sites traversed by foot, the GPS locations of DRF, Priority and unfamiliar (opportunistic) species were noted. Particular attention to searching was given to areas with soil and vegetation associations that supported DRF species.

A review of the Western Botanical Database as provided by Tiwest was conducted by Woodman Environmental Consulting. The locations of DRF and Priority species encountered during the survey by Woodman Environmental Consulting in 2006, in addition to a number of significant species observed by Western Botanical (2005a,b, 2006) were recorded on the final structural plant community map (Figures 1.1 and 1.2).

4.3 *Phytophthora cinnamomi*

The project area was interpreted for potential *P. cinnamomi* infestations during spring 2006 by an accredited dieback interpreter from Glevan Consulting Ptd Ltd (Glevan 2006). The interpretation involved inspection of remnant native vegetation along all access tracks and water gaining areas on the exploration leases and boundaries with adjacent vegetation. In addition, drainage lines outside of the project area that have the potential to transport the fungus were also inspected.

All areas surveyed were traversed both in a vehicle and on foot. Samples of soil and vegetation material from dead or dying indicator plant species were collected to be analysed for the presence of *P. cinnamomi*. Those species generally considered to most reliably indicate the presence of *P. cinnamomi* were used to delineate the disease boundaries within the study area. These included (but were not limited to) *Banksia, Xanthorrhoea, Patersonia, Adenanthos, Dryandra, Isopogon* and *Petrophile* species.

Any obvious disease boundaries along the route were marked in the field using day-glo flagging tape. Any disease boundaries and sample locations were recorded using GPS units (GDA94 Datum, Zone 50).

Samples were stored in cool containers for transport to the Vegetation Health Service Branch Laboratory in Kensington. Vegetation tissue samples were surface sterilised with ethanol and then plated directly onto the selective agar. All soil samples were inundated with sterile distilled water and baited with *Eucalyptus sieberi* cotyledons. The cotyledons were plated onto selective agar after 5 days if they showed signs of infection (loss of purple colouring). The remainders of the cotyledons were plated after 10 days.

All fungi growing on the agar plates after baiting were isolated where possible and analysed for the presence of *Phytophthora* species using the taxonomic key described by Stamps *et al.* (1990). Observations of hyphal swellings indicate the presence of *Phytophthora cinnamomi*.

Following receipt of the sample analysis results, an assessment of the significance of *P. cinnamomi* within the project area was determined and mapped for future management of the disease (Glevan 2006).

4.3.1 Disease Interpretation and Mapping Terminology

The following definitions relate to terminology used in later sections of this report.

Cleandown: The removal of soil, soil slurry, mud and vegetation material from vehicles, plant or machinery using either compressed air or a brush for dry material or a high pressure water washdown unit for wet material.

Hygiene Procedures: Tasks (e.g. Cleandown) that must be completed to ensure that plant pathogen (*P. cinnamomi*) is not spread into protectable areas.

***P. cinnamomi* free (Uninfested areas):** Areas of native vegetation that an accredited interpreter has determined to be free of plant disease symptoms that would indicate the presence of the pathogen *P. cinnamomi*.

***P. cinnamomi* infested (Infested areas):** Areas of native vegetation that an accredited interpreter has determined have plant disease symptoms consistent with the presence of the pathogen *P. cinnamomi*.

Uninterpretable: Areas in which indicator plants are absent or too few to determine the presence or absence of disease caused by *P. cinnamomi*. These areas will include agricultural areas, areas that have been significantly disturbed and some native vegetation areas with few or no indicator species such as wetlands.

Unmappable: Areas that are sufficiently disturbed so that *P.cinnamomi* occurrence mapping is not possible at the time of inspection. This category is a subset of the Uninterpretable category.

Protectable Area: Defines DEC managed land over which the hygiene rule, for the plant pathogen *Phytophthora cinnamomi*, of 'clean on entry' will apply (CALM 2003).

Unprotectable Area: Consist of all areas not classed as Protectable (CALM 2003).

5 RESULTS

5.1 Flora

A total of 376 vascular plant taxa belonging to 59 plant families were recorded within the Dongara project area during the survey in Spring 2006 (Appendix C). The dominant families were Myrtaceae (63 taxa), Proteaceae (54 taxa) and Cyperaceae (22 taxa).

Two Declared Rare Flora species were recorded within the project area, *Paracaleana dixonii* and *Stawellia dimorphantha*. *Paracaleana dixonii* is a member of the Orchidaceae family and is a tuberous perennial herb to 0.2m (Plate 1). *P. dixonii* has an unusual flowering period that occurs between the months of late October and January (Hoffman and Brown 1998). This niche, where the conditions are hot and dry, is achieved by producing a succulent, nutrient storing stem during the wetter months of spring. Only 1 plant was recorded of this species in the 2007 survey, within a detailed recording site (Figure 1.1 and 1.2). This site was recorded within community H5, described as 'Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes'.

Plate 1: *Paracaleana dixonii* (DRF) photo by G. Woodman

Stawellia dimorphantha is a member of the Anthericaceae family and is a stilt rooted perennial to 0.2m (Plate 2). *S. dimorphantha* typically flowers between the months of June and November. Field experience has shown that this species responds well to disturbances such as clearing. *S. dimorphantha* was recorded in a number of detailed sites in addition to opportunistic observations in the field (Figures 1.1 and 1.2). In general, where *S. dimorphantha* was observed in undisturbed vegetation communities, the number of individuals recorded was typically 1 or 2 plants. In contrast, larger patches of individuals were observed on access tracks and previously rolled seismic lines. *S. dimorphantha* was recorded in a number of vegetation community types including W3, W4, W5, W6, H3, S1, T1, T2 and T3 (Appendix D, Figures 1.1 and 1.2).

Plate 2: *Stawellia dimorphantha* (DRF) photo by S.J. Patrick

Records held by DEC (2007b) reveal the DRF species *Caladenia wanosa* has previously been recorded in the local vicinity of the project area. *Caladenia wanosa* is a member of the Orchidaceae family and is a perennial herb to 0.2m with cream and red flowers between August and September (Plate 3). There is only 1 record of this species adjacent to the project area, recorded outside the mapped area which is likely to correspond with community H5 'Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes' (Plate 3).

Plate 3: *Caladenia wanosa* (DRF) photo by A.P. Brown, S.D. Hopper and S. Armstrong

A total of 19 Priority species were recorded in the survey area by Woodman Environmental Consulting during spring 2006. In addition, the Priority species *Guichenotia alba* (P3), *Synaphea* ?*aephynsa* (P3) (out of mapping area), *Tricoryne* sp. Eneabba (E.A. Griffen 1200) (P2), *Persoonia filiformis* (P2) and *Verticordia luteola* var. *luteola* (P3) were recorded by Western Botanical in spring 2005 during detailed searching of drill lines for the Tiwest 2005 exploration drilling program. The data from these observations in addition to data provided by DEC (2007b) have been combined in Table 4.

In addition to Rare and Priority Flora, 2 undescribed *Stylidium* species were recorded by Woodman Environmental Consulting during spring 2006. These species were previously collected during surveys conducted by Western Botanical (2005a,b, 2006) and have been confirmed by specialist taxonomists working on the *Stylidium* group. Furthermore, previous surveys by Western Botanical have identified a third species of *Stylidium* that has not been

described and a fourth species, *Stylidium carnosum* subsp. Narrow leaves (J.A Wege Jaw 490) which is currently being submitted for priority status (Table 5).

Stylidium species 1, 2 and 3 are related to the *Stylidium piliferum* complex which is currently under review, therefore a conservation status can not be assigned to these species at this time in the absence of additional taxanomic review and field survey. The *Stylidium piliferum* complex is widespread and there are over 300 specimens in the West Australian Herbarium to be sorted. It is believed that *Stylidium* species 1, 2 and 3 have only been collected within the Tiwest Dongara Leases and their potential conservation significance can not be discounted. These species will require further survey within and beyond the Tiwest Dongara tenements.

Stylidium carnosum is widespread throughout the south west and requires fire to stimulate flowering. Consequently, *Stylidium carnosum* has been poorly collected across its range. The specimen collected in the Tiwest Dongara lease has unusual narrow leaves and hence has been considered as a possible new taxon, namely *Stylidium carnosum* subsp. Narrow leaves (J.A. Wege 490). It is expected that this species will be listed on Florabase with a Priority 1 rating during 2007. This unusual form of *Stylidium carnosum* has been collected previously by Juliet Wege near Lake Indoon, west of Eneabba. This species will require further survey to give a clearer indication of its taxonomic and conservation significance.

Table 4: Priority Flora Recorded in the Dongara Project Area during the Surveys Conducted by Woodman Environmental Consulting (2006) and Western Botanical (2005a,b, 2006) in Additon to Data Provided by the Department of Environment and Conservation (2007a).

Species	Family	No. of Locations	Communities recorded	Comments
Acacia latipes subsp. *licina*(P3)	Mimosaceae	1	out of mapped area	Pungent shrub to 1.2m. Yellow flowers between June – Sep. Found on white sand, granit e and limestone
Acacia vittata (P2)	Mimosaceae	5	out of mapped area	Dense rounded shrub to 4m with yellow flowers in Aug. Found on grey sands and clays on the margins of seasonal lakes.
Baeckea sp. Walkaway (A.S George 11249) (P3)	Myrtaceae	4	T3, W4	A dense multistemmed shrub to 2m. White flowers between Dec – Jan. Found on yellow, brown or white sand
Banksia elegens (P4)	Proteaceae	25	H2, H3, T1, T2, T3, W3, W4, W5, W6, W7	Fire tolerant shrub to 4m. Yellow green flowers between Oct – Nov. Found on yellow, white or red sands on sandplains and dunes
Banksia scabrella (P4)	Proteaceae	13	H3, H5 and W5	Many branched shrub to 2m. yellow, purple flowers between Sep – Jan. Found on white, grey or yellow sands on sandplains and lateritic ridges
Calytrix chrysantha (P3)	Myrtaceae	5	W3, W5	Shrub to 1.3m with yellow flowers between Dec – Feb. Found on white, grey or yellow sand flats.
Calytrix ecalycata subsp. *ecalycata* (P3)	Myrtaceae	1	out of mapped area	Erect shrub to 1.5m with yellow flowers between Jul – Oct. Found on a variety of soils.
Calytrix eneabbensis (P3)	Myrtaceae	2	out of mapped area	Shrub to 1m with purple, pink and yellow flowers between Jul – Oct. Found on white, grey or yellow sand over laterite.
Calytrix superba (P3)	Myrtaceae	1	out of mapped area	Shrub to 1m with pink flowers. Found on sand over laterite.
Comesperma acerosum (P3)	Polygalaceae	2	W5	Erect shrub to 0.5m with blue or purple flowers between Sep – Dec. Found on sandy limestone and lateritic gravels
Darwinia sanguinea (P4)	Myrtaceae	1	H5	Prostrate shrub to 2m with red/purple flowers between Aug – Dec. Found on white and grey sands over gravelly laterite
Eremaea acutifolia (P2)	Myrtaceae	2	W6	Spreading shrub to 0.7m with orange and pink flowers between Aug – Nov. Found on grey or yellow sand
Eucalyptus macrocarpa subsp. *elachantha* (P4)	Myrtaceae	10	H3, H5	Spreading mallee to 4m. Red or pink flowers between Aug – Dec. Found on white and grey sands over laterite on sandplains, hills and ridges

Species	Family	No. of Locations	Communities recorded	Comments
Eucalyptus macrocarpa x *pyriformis*	Myrtaceae	1	out of mapped area	Erect open mallee to 6m. Red flowers between Apr-Oct. Found on sand and lateritic soils.
Eucalyptus zopherophloia (P4)	Myrtaceae	1	W3	Spreading mallee to 4m. Cream, white flowers between Oct – Jan. Found on grey or white sand with coastal limestone
Gastrolobium callistachys (P4)	Papilionaceae	1	W6	Weeping shrub to 3m with yellow and orange flowers between Sep – Nov. Found on sandy soils and granite outcrops.
Grevillea erinacea (P3)	Proteaceae	1	H4	Prickly, spindly shrub to 1.8m with green, white and cream flowers between Jul – Dec. Found on white, grey and yellow sands and laterite
Guichenotia alba (P3)	Sterculiaceae	6	H3, H5	Slender shrub to 0.5m. White flowers between Jul – Aug. Found on sandy, gravelly soils in low flats and depressions
Guichenotia quasicalva (P2)	Sterculiaceae	2	out of mapped area	Erect shrub to 0.5m with blue or purple flowers between Sep – Oct. Found on sandy clay over laterite in drainage lines.
Hakea polyanthema (P3)	Proteaceae	132	H2, H3, H5, T2, T3, W1, W3, W4, W5, W5a, W6	Shrub to 2m with white flowers between Aug – Sep. Found on grey and white sands and loam
Hemiandra sp. ?Eneabba (H. Demarz 3687) (P1)	Lamiaceae	7	H3, T3, W5	Straggly shub to 0.9m. Blue, violet flowers in February growing on sandy soils
Hemiandra sp. Eneabba (H. Demarz 3687) (P1)	Lamiaceae	8	H3, W5	a/a
Hemigenia saligna (P3)	Lamiaceae	1	out of mapped area	Shrub to 1m with blue or purple flowers between Jul – Oct. Found on sandy and lateritic soils
Homalocalyx chapmanii (P1)	Myrtaceae	1	out of mapped area	Shrub to 0.5m with red, pink and purple flowers between Sep – Oct. Found on yellow, grey or brown sands and granite outcrops
Hopkinsia anoectocolea (P3)	Restionaceae	14	W1, W3, S1	Rhizomatous, perenial to 1m. Brown flowers between Sep – Dec. Found on white or grey sands and in saline depressions.
Hypocalymma gardneri (P2)	Myrtaceae	1	W5	Shrub to 0.3m with yellow flowers between Aug – Sep. Found on grey and brown sands and laterite
Hypocalymma tetrapterum (P3)	Myrtaceae	1	out of mapped area	Shrub to 0.9m with white flowers in Aug. Found on grey sands and laterite in riverbanks and breakaways
Isopogon tridens (P3)	Proteaceae	41	H3, H5, T3, W5, W6	Bushy shrub to 1.2m. White, cream, purple flowers between Jun – Aug. Found on grey or white sand and laterite

Species	Family	No. of Locations	Communities recorded	Comments
Lasiopetalum ogilvieanum (P1)	Sterculiaceae	2	W5	Shrub to 1.5m Pink, white flowers between Jul – Oct. Found on white, grey or yellow sands and stoney soils.
Mesomelaena stygia subsp. *deflexa* (P1)	Cyperaceae	4	H3, T3	Tufted grass-like sedge to 0.5m. Brown, black flowers between Mar – Oct. Found on white or grey lateritic sands and gravelly clays
Olax scalariformis (P3)	Olacaceae	24	W5, H3, W6	Shrub to 0.8m with cream, white flowers between Oct – Nov. Found on sand and sandy loams.
Persoonia filiformis (P2)	Proteaceae	2	H3	Spreading shrub to 0.4m. Yellow flowers between Nov – Dec. Found on yellow or white sands over laterite
Persoonia rudis (P3)	Proteaceae	9	H3, W5, T3	Erect or spreading shrub to 1m. Yellow flowers between Sep – Jan. Found on white, grey or yellow sands, sometimes over laterite
Schoenus griffinianus (P2)	Cyperaceae	9	W5, W6	Small tufted perennial to 1m., flowering between Sep – Oct. Found on white sands.
Schoenus sp. Eneabba (P1)	Cyperaceae	6	W6	n/a
Stachystemon axillaris (P4)	Euphorbiaceae	5	W5, W7	Diffuse shrub to 1.2m. Green, yellow, purple flowers between Feb – Oct. Found on white and grey sand and lateritic gravels
Stylidium diuroides subsp. *paucifoliatum* (P4)	Stylidiaceae	6	H3, W6	Erect perennial herb to 0.4m. Yellow flowers between Sep – Nov. Found on white, grey or yellow sandplains
Stylidium drummondianum (P3)	Stylidiaceae	3	out of mapped area	Rosetted perennial to 0.2m with pink flowers between Aug – Sep. Found on sand and clay over laterite
Stylidium pseudocaespitosum(P2)	Stylidiaceae	1	W6	Rosetted perennial to 0.2m with yellow flowers between Sep – Nov. Found on white, grey or yellow sands over laterite.
Stylidium torticarpum (P3)	Stylidiaceae	1	out of mapped area	Perennial herb to 0.3m with pink flowers between Sep – Nov. Found on sandy clay and clay loams in depressions.
Synaphea oulopha (P1)	Proteaceae	1	out of mapped area	Compact shrub to 0.2m with yellow flowers between Jul – Oct. Found on grey sands, loam and laterite.
Synaphea sparsiflora (P2)	Proteaceae	1	out of mapped area	Shrub to 0.6m with yellow flowers between Aug – Sep. Found on sandy loam over laterite.
Thysanotus glaucus (P4)	Anthericaceae	2	out of mapped area	Perennial herb to 0.2m with purple flowers between Oct – March. Found on white, grey or yellow sands and gravels.
Tricoryne sp. Eneabba (E. A Griffin 1200) (P2)	Anthericaceae	11	H3	Woody, rhizomatous, perennial herb to 0.5m. Yellow flowers between Sep – Jan. Found on various sandy soils, clays, loams, lateritic gravels, and limestone

Species	Family	No. of Locations	Communities recorded	Comments
Triglochin protuberans (P3)	Juncaginaceae	1	out of mapped area	Annual herb to 0.1m with green flowers. Found on red loams and grey muds in wet areas.
Verticordia ?*blepharophylla* (P2)	Myrtaceae	1	H3	Erect shrub to 1m with pink, purple flowers between Nov – Feb. Found on white, grey or yellow sands and sandy clay in damp depressions
Verticordia blepharophylla (P2)	Myrtaceae	1	H5, W6	a/a
Verticordia dasystylis subsp. *oestopoia* (P1)	Myrtaceae	1	out of mapped area	Spreading shrub to 0.4m with cream and yellow flowers in Oct. Found on gritty soils over granite
Verticordia luteola var. *luteola*	Myrtaceae	1	W6	Slender shrub to 1.4m. White, yellow flowers between Nov – Dec. Found on grey sands over gravel
Verticordia luteola var. *rosea* (P1)	Myrtaceae	10	out of mapped area	Slender shrub to 2m with pink, green and brown flowers between Dec – Jan. Found on white sands.

Table 5: Undescribed *Stylidium* Species Recorded in the Dongara Project Area during the Surveys conducted by Woodman Environmental Consulting (2006) and Western Botanical (2005a,b and 2006)

Label by Woodman Environmental Consulting (2006)	Label by Western Botanical (2005)	No. of Locations	Communities Recorded	Conservation Status
Stylidium sp. 1	*Stylidium* sp nova 'pink flowers' (KM0318, AR1019)	5	T3, H3, W6	Conservation status unknown
Stylidium sp. 2	*Stylidium* sp nova '*Stylidium piliferum* complex' (KM0268)	201	W6, H3, T3	Conservation status unknown
Stylidium sp. 3	*Stylidium* sp nova 'golden yellow glands on hypanthium' 'Stylidium piliferum complex' (DET0075)	1	H3	Conservation status unknown
Stylidium carnosum subsp. Narrow leaves (J.A. Wege 490)	*Stylidium* sp nova "60-70 cm tall"	3	H3	Is likely to be categorised as a Priority 1 species

A total of 15 introduced (weed) taxa were recorded within the project area (Table 6).

In general, weed invasion within the project area was very low. However, weeds were prevalent in disturbed areas adjacent to farming properties that surround the tenements. Site 120 recorded the highest incidence of weeds (80%) situated in community F1 which is described as a Low Forest of *Melaleuca rhaphiophylla* over Open Dwarf Scrub on sandy clay in drainage lines. Site 143 recorded approximately 10% weed cover and is located in community W1 which is described as a Woodland of *Eucalyptus camaldulensis* over mixed shrubs dominated by *Acacia* spp. and *Melaleuca* spp. on sandy clay soils in valleys and floodplains. These communities are seasonally inundated with water and during the dry season the exposed bare ground is dominated by introduced grasses and paddock weeds.

Table 6: Introduced Flora Recorded in the Dongara Project Area

Species	Communities
**Aira cupaniana*	T2, W1, W5
**Anagallis arvensis*	W1, W2, W3, W4
**Anagallis arvensis* var. *caerulea*	T2
**Avena barbata*	F1
**Brassica tournefortii*	F1
**Briza maxima*	F1, W1, W4
**Briza minor*	W1
**Centaurea melitensis*	W1, W2
**Ehrharta longiflora*	W1, W3, W4
**Hypochaeris glabra*	T2, W1, W3, W6
**Pentaschistes airoides*	H4, W3, W6
**Polypogon monspeliensis*	W1
**Sonchus oleraceus*	W3
**Ursinia anthemoides*	H2, H4, H5, H6, W1, W3, W4, W5, W5a, W6, W7
**Wahlenbergia capensis*	W5, W6

None of the weed species recorded during the spring 2006 survey are listed as Declared Plants by Agriculture Western Australia (DAF 2007).

5.2 Vegetation

19 structural plant communities were described and mapped within the Dongara Project Area:

Forests

F1: Low Forest *of Melaleuca rhaphiophylla* over Open Dwarf Scrub on sandy clay in drainage lines.

Woodlands

W1: Woodland of *Eucalyptus camaldulensis* over mixed shrubs dominated by *Acacia* spp. and Melaleuca spp. on sandy clay soils in valleys and floodplains.

W2: Low Woodland of *Melaleuca preissiana* and *Casuarina obesa* on clay soils in basins and floodplains.

W3: Low Woodland of *Eucalyptus erythrocorys* over Thicket to Low Heath dominated by *Acacia* spp. or *Melaleuca* spp. on sand over limestone on mid to upper slopes.

W4: Low Woodland dominated by *Banksia prionotes* on yellow sand with occasional limestone outcropping on upper slopes and ridges.

W5: Open Low Woodland of *Eucalyptus todtiana* with occasional *Xylomelum angustifolium* and *Banksia* spp. over Open Shrubs to Heath dominated by myrtaceous and proteaceous species on grey sand on mid to upper slopes.

W5a: Open Low Woodland of *Eucalyptus todtiana* over Open Low Scrub dominated by *Calothamnus quadrifidus* on grey brown sand in creeklines.

W6: Open Low Woodland to Heath of *Banksia attenuata* and *Banksia menziesii* over mixed myrtaceous and proteaceous shrubs on grey and brown sand on mid to upper slopes.

W7: Open Low Woodland of *Eucalyptus todtiana* and *Actinostrobus pyramidalis* over Heath of mixed shrubs on grey brown sand on lower to mid slopes and swales.

The project area supports a diverse range of woodlands. The structures of these woodlands are strongly influenced by fire, with frequent burning often suppressing the stature of trees. Community W5 is the most prominent and widespread woodland community and dominates large expansive areas to the south. W5 is characterised by *Eucalyptus todtiana* and occasional *Xylomelum angustifolium* on grey sands on mid to upperslopes. A wetter form of community W5 is located along a creekline to the east of the project area and has been identified as W5a.

The west of the project area is dominated by W3 which supports stands of *Eucalyptus erythrocorys* on mid to upper slopes with shallow soils and frequently exposed limestone outcropping. *Eucalyptus erythrocorys* is a fire sensitive species with strong root systems that penetrate limestone crevices. Shrub species are less likely to penetrate the limestone rock, therefore the shrub layer is typically open and the intensity of fires is subsequently reduced (Beard 1979).

East of the *Eucalyptus erythrocorys* association, the upperslopes and ridges are dominated by community W4 which is characterised by *Banksia prionotes*. Yellow sands overlay sub-surface limestone which is occasionally exposed. The grey brown sands in the western half of the project area are typically dominated by community W6 which comprises a woodland or heath of *Banksia attenuata* and *Banksia menziesii* over mixed shrubs.

Community W1 comprises *Eucalyptus camaldulensis* woodlands on sandy clay soils in valleys and flood plains and predominantly occurs in the south west of the project area. The wetter clay basins support community W2 with stands of *Melaleuca preissiana* and *Casuarina obesa*. Community W2 is poorly represented within the project area, occupying a small portion of the overall woodland community structure.

Community W7 is characterised by *Eucalyptus todtiana* and *Actinostrobus pyramidalis* on lower to mid slopes adjacent to drainage lines and basins. This community is found in the north west and south west of the project area, with small isolated pockets in the center of the project. In addition to W1 and W2, community W7 is poorly represented in the project area.

Scrub

S1: Low Scrub dominated by *Jacksonia hakeoides*, *Melaleuca systena*, *Acacia blakelyi* and *Hakea trifurcata* on yellow sand over limestone on mid slopes.

Community S1 is located to the south west of the project area and comprises a small localised area of scrub on sandy soils with sub-surface limestone.

Thickets

T1: Thicket dominated by *Actinostrobus pyramidalis* on clayey soils in basins and lower slopes.

T2: Thicket dominated by *Allocasuarina campestris* and *Acacia* spp. on sandy clay on lower slopes, gullies and basins.

T3: Thicket to Heath dominated by *Banksia hookeriana* and *Banksia attenuata* on yellow sand on mid to upper slopes.

T4: Dense Thicket of *Melaleuca huegelii* over Open Dwarf Scrub on sandy clay over limestone on lower slopes.

Communities T1 and T2 form thickets on clays and sandy clays in drainage areas. These communities form part of a chain of small wetland areas with a north – south orientation. Community T4 is a small area located to the south west of the project area and comprises a dense thicket of *Melaleuca huegelii* on sandy clays over limestone on lower slopes. Community T3 is characterised by *Banksia attenuata* and *Banksia hookeriana* thicket to heath on mid to upperslopes. This community is widespread throughout the project area and is comprised of large extensive areas on well drained yellow sands.

Heaths

H1: Heath dominated by *Melaleuca systena* in pans with impeded drainage

H2: Heath dominated by *Banksia leptophylla*, *Calothamnus hirsutus* and myrtaceous species in pans with impeded drainage

H3: Heath dominated by *Hakea polyanthema*, *Beaufortia elegens*, *Calothamnus blepharospermus* or *Eremaea beaufortioides* over Dwarf Scrub dominated by *Ecdeiocolea monostachya* on brown or yellow sand on lower to upper slopes.

H4: Heath dominated by *Acacia* spp. *Calothamnus quadrifidus, Hakea lissocarpha* and *Melaleuca leuropoma* with emergent *Eucalyptus* spp. on grey sand on lower slopes.

H5: Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes

Community H1 is a heath dominated by *Melaleuca systena* in a pan with diatomaceous earths and impeded drainage. This community is small and localised near the centre of the project area and is part of the north-south belt of wetland communities. In addition, Community H2 forms part of this belt and is represented by a number of small pockets of wetland communities dominated by *Banksia leptophylla, Calothamnus hirsutus* and a number of myrtaceous species. Community H2 is mainly comprised of smaller pockets of heath located to the north of the project area. A larger, isolated area of H2 is located near the southern boundary of the project area.

Community H3 is comprised of *Hakea polyanthema* heath and forms large expansive areas to the north and east of the project area on brown or yellow sands on various slopes.

Community H4 is represented by small areas in the project area on the lower slopes adjacent to drainage lines. Two small pockets of H4 are located near the southern boundary, whereas the third location forms an elongated polygon in the east of the project area.

Community H5 is found on sandy lateritic soils and is located near the eastern margins of the project area. The community consists of large areas of lateritic heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* and is likely to extend east beyond the project area.

The majority of the vegetation within the Dongara tenements is in a Pristine or Excellent condition. However, the vegetation is subjected to frequent fires and the boundaries of the project area are adjacent to previously cleared agricultural land with encroaching weed infestations. Previous clearing currently under rehabilitation from 3D Seismic Surveys lattice the project area and are visible from the aerial photographic maps.

5.3 *Phytophthora cinnamomi*

The majority of the project area was determined to be mappable for dieback interpretation (Glevan 2006). There were no recorded infestations of *Phytophthora cinnamomi* in the mappable area. Four samples of root and soil material were collected for analysis from suspect *Banksia hookeriana, Banksia menziesii* and *Xanthorrhoea preissii* plants. None of these samples returned a positive result for *Phytophthora cinnamomi*.

A small part of the project area was determined to be unmappable for dieback interpretation due to the recent burn in adjacent vegetation. Coincidently, the unmappable areas were determined to be at the greatest risk of dieback infestation. These areas include the public, gravelled Mt Adams Road and the access road to the Beharra Springs gas plant.

6 DISCUSSION

6.1 Flora and Vegetation

The Dongara project area is situated on the Geraldton Sandplain GS3- Lesueur Sandplain subregion. This region contains a large number of DRF species and exhibits extremely high levels of endemic flora. Over 250 species of the sandplain are endemic to the GS3 subregion (Desmond and Chant 2001).

The survey was conducted during the months of spring to coincide with the flowering periods of most annual and perennial species within the project area. The number of raindays recorded for Geraldton during the months of 2006 was approximately half of that recorded for average historical records (34 and 59.7 raindays respectively)(Bureau of Meterology 2007). However, due to the intensity of the survey and the duplicate representation of sites within most communities observed, it is estimated that the 2006 survey recorded approximately 80 percent of the total species expected within the project area.

Two DRF species were recorded during the survey by Woodman Environmental Consulting, *Paracaleana dixonii* and *Stawellia dimorphantha*. One individual of *P. dixonii* was recorded in the H5 lateritic community to the east of the project area. There are 6 records of this species in the West Australian Herbarium collected from grey and lateritic sands. Brown (1998) report that *P. dixonii* grows in deep sandy soils in shrubland amongst scattered *Banksia* spp. *P. dixonii* has been collected on a variety of soils, but demonstrates some preference to shallow sands over laterite in heath communities (Pers. comm A. Brown). Collections of *P. dixonii* outside of the project area include Eneabba, Coomallo Creek, Sullivan Rock, Arrowsmith, Yardanooka and Moore River National Park (Appendix B). It is recommended that exploration drill lines avoid Community H5 to minimise the risk of impacting potential populations. Drill lines that intercept Community H5 will need to be surveyed during Spring to coincide with this species flowering period.

Stawellia dimorphantha has been recorded in a number of communities throughout the project area, namely W3, W4, W5, W6, H3, S1, T1, T2 and T3. Tiwest have previously applied for a 'Permit to Take' up to 120 individuals of *S. dimorphantha,* which expires on the 30th June 2007, for exploration activities within the project area. Field observations suggest that this species is a disturbance opportunist. In native vegetation, populations of more than 10 individuals are rarely seen. However, on disturbed fire-breaks and cleared tracks larger populations of *S. dimorphantha* are observed. It is unlikely that the drilling exploration program will have a significant impact on the distribution of this species. It would be preferred that the drilling program be aligned with the previously rehabilitated 3D seismic lines to minimise the impacts of clearing. However, this means that the likelihood of encountering individuals of *S. dimorphantha* is increased. *S. dimorphantha* has a limited distribution south east of Dongara. Recorded observations of this species have increased in recent years. Subsequently, an application for the removal of *S. dimorphantha* from the DRF list has been submitted to the Department of Environment and Conservation by Woodman Environmental Consulting, which is currently being reviewed.

Caladenia wanosa was not identified during the broadscale plant community mapping program or during detailed surveys of drill lines in 2005, however it has been recorded adjacent to the project area, outside the mapped area which is likely to correspond with

community H5. This species was located close to the border of the project area and as such its habitat is probably contiguous with habitats present within the eastern portion of the mapped area. There is a high potential for this species to be present within Community H5 within the project area and as such should be searched for during its peak flowering period.

The Department of Environment and Conservation databases reveal two additional DRF species previously recorded within the search area for the Dongara tenements, *Eucalyptus leprophloia* and *Thelymitra stellata*. These species were recorded to the east and south east of the project outside of the mapped area and are likely to be associated with the lateritic H5 community or similar escarpment associations. There is a remote potential for these species to be present within the project area.

A total of 19 Priority flora were recorded during the spring assessment by Woodman Environmental Consulting. Five additional Priority flora were recorded by Western Botanical (2005a, b) during detailed intensive searches for DRF and Priority species for Tiwest's exploration drilling program. None of the Priority flora recorded during the survey by Woodman Environmental Consulting and Western Botanical (2005a,b, 2006) are restricted to the project area. Therefore it is unlikely that the exploration program will have a significant impact on populations of Priority flora within the project area.

Three species of *Stylidium* related to the *Stylidium piliferum* complex were recorded within the project area (Stylidium sp.1, 2 and 3). It is believed that these specimens have not been previously collected outside of the project area (A. Lowrie Pers. Comm.). The *Stylidium piliferum* complex is currently under review. Due to the number of specimens to be sorted in the West Australian Herbarium it is unlikely that these species will be categorised or formally described within the near future. Consequently, conservation significance can't be assigned to these species. The distribution of these *Stylidiums* within the project area is unknown and will require further survey during spring to gain knowledge of their biology, habitat requirements and extent. *Stylidium* expert Juliet Wege has requested that future collections include photographs of flowers and spirit samples aid in identification.

An additional *Stylidium* species related to *Stylidium carnosum* was recorded by Western Botanical during 2005. This species has recently been listed on Florabase with the phrase name *Stylidium carnosum* subsp. Narrow leaves (J.A. Wege 490) and is currently under review for an appropriate conservation code. It is likely to receive a Priority 1 status, otherwise it will be classed as a Priority 2 species (J. Wege Pers. Comm). This species can reach 80cm in height when in flower and can be easily distinguished from other *Stylidium* species. Additional survey of this unusual form of *Stylidium carnosum* is required to discern whether it is a distinguishable subspecies, requiring conservation status, or a variation within the *Stylidium carnosum* group which to date has been poorly collected.

The impact and distribution of weeds within the Dongara tenements was low. Areas with the highest incidence of weeds were in degraded areas on the boundaries of the project area which are adjacent to various pastoral leases. None of the recorded weeds are Declared Plants defined by the Department of Agriculture and Food (2007).

6.2 Regional Significance & Conservation Status of Plant Communities

The project area is located within the southern section of the Geraldton Sandplains Biogeographical Region (Environment Australia, 2000), specifically within the GS3 – Lesueur Sandplain (Desmond and Chant 2001). The project area occurs in several vegetation associations as described by Shepard et al (2000) (Table 1, Figure 2). Association 392 has been given a 'High' priority rating. There are only 1,554 ha (42.6%) of this community remaining of its pre-european extent of which 16.4% is held in reserves. This community was not observed during the mapping by Woodman Environmental Consulting in 2006. A review of traverses conducted by Beard during the broadscale mapping (1976) reveals that Association 392 may have been extrapolated from Traverse 3. This traverse is located towards the south western boundary of the project area. It is therefore unlikely that the *Melaleuca thyoides* thickets characteristic of Association 392 are located in the project area. However, it is recommended that these areas be revisited during additional survey work to be conducted during 2007 to support approval of a mining proposal. In addition, it is recommended that the proposed exploration drill lines be aligned to avoid this association (Figure 2). The proposed additional quadrat based floristic studies will provide a wider understanding of the distribution of Association 392 and the basis for appropriate management if required.

None of the plant communities mapped within the project area are currently listed or proposed for listing as Threatened Communities by the Department of Conservation and Land Management. 19 structural plant communities were described and mapped within the Dongara Project Area. A number of communities mapped are considered to be poorly represented within the project area. This is partially due to the high level of diversity between wetland communities, particularly in the region of the wetland belt that is orientated north – south in the project area. These wetter communities are listed below:

F1: Low Forest *of Melaleuca rhaphiophylla* over Open Dwarf Scrub on sandy clay in drainage lines.

W2: Low Woodland of *Melaleuca preissiana* and *Casuarina obesa* on clay soils in basins and floodplains.

W5a: Open Low Woodland of *Eucalyptus todtiana* over Open Low Scrub dominated by *Calothamnus quadrifidus* on grey brown sand in creeklines.

H1: Heath dominated by *Melaleuca systena* in clay pans.

Wetlands situated on the coastal plain between Lancelin and Dongara (described as the System 5 Region) were assessed for ecological significance by the Semeniuk Research Group (1994). The aim of the study was to report on wetlands within the System 5 Region and provide recommendations to the Australian Heritage Commission on the listing of various areas on Register of the National Estate.

The area to the south-west of the project where an incidence of community W2 was recorded corresponds with the Australian Heritage Site 'Arrowsmith Lake Area, Brand Hwy, Dongara, WA' (DEWR 2007). This community is protected and is listed on the Register of the National Estate. The Heritage listing includes an area of approximately 10,000ha surrounding the lower reaches of the Arrowsmith River, including Arrowsmith Lake and Arrowsmith Hill. This

community supports unique flora and a range of waterfowl and land birds. Key threatening process to the Arrowsmith River include mining, feral animals, *Phytophthora* dieback, altered fire regimes, increases in flow and grazing pressures (Desmond and Chant 2007). The Arrowsmith River Suite is described by Semenuik (1994) as an area of "microscale creeks and a river (Irwin River) that arise in the Arrowsmith Region and debouch into the Eneabba Plain, occasionally traversing the Coastal Limestone and reaching the coast". The wetlands are maintained by precipitation and runoff. The surface water is described as subhaline with muddy sand and lateritic sedimentation. The length and continuity of the Arrowsmith Suite and its associated riparian vegetation provide a corridor for faunal movement.

The Yardanogo Suite contains one wetland, the Yardanogo Swamp. This swamp corresponds with an incidence of community W1 and W2 recorded in the north of tenement E70/2430, which includes the small section of tenement that has been separated from the bulk of E70/2430 and occurs on private property enclosed within the southern portion of the Yardanogo Nature Reserve. Yardanogo swamp is a seasonally inundated basin underlain by coffee rock which ponds precipitation (Semeniuk 1994). There is evidence of recharge from minor seepage via adjacent dunes. The wetland has been partially cleared and grazed, however the remaining vegetation provides habitat for fauna.

The Beharra Spring Suite contains a series of seasonally waterlogged basins, known as damplands, which correspond to the north-south belt of various wetland communities central to the project area. The wetland communities H1, H2, T1, T2 and W1 mapped by Woodman Environmental Consulting form part of this Suite described by Semeniuk (1994). The Beharra Spring itself is located at GPS location 320837 E 6729621 N within community W1 and is associated with impervious clays. Areas adjacent to the spring have been previously cleared.

The north western boundaries of the project area are on the fringes of the Mimmegara Suite. It is likely that vegetation communities T1 and T2 are associated with this suite. This suite is considered to be locally significant by Semeniuk (1994) due to the presence of "seasonal freshwater sumplands and damplands in an otherwise water deficient area". The surrounding natural vegetation enhances biodiversity, provides a buffer to hydrological disturbances and supports fauna habitats.

Other communities that are poorly represented in the project area include:

W7 Open Low Woodland of *Eucalyptus todtiana* and *Actinostrobus pyramidalis* over Heath of mixed shrubs on grey brown sand on lower to mid slopes and swales.

H4 Heath dominated by *Acacia* spp. *Calothamnus quadrifidus, Hakea lissocarpha* and *Melaleuca leuropoma* with emergent *Eucalyptus* spp. on grey sand on lower slopes.

S1 Low Scrub dominated by *Jacksonia hakeoides, Melaleuca systena, Acacia blakelyi* and *Hakea trifurcata* on yellow sand over limestone on mid slopes.

T4 Dense Thicket of *Melaleuca huegelii* over Open Dwarf Scrub on sandy clay over limestone on lower slopes.

The remainders of the vegetation communities generally have wider distributions throughout the project area, forming larger expansive areas - particularly communities W5, H3, T3 and to a lesser extent H5.

The Yardanogo Nature Reserve is situated adjacent to the north western border of the project area and has been previously mapped as part of the survey by Woodman Environmental Consulting for the ARC Energy and Origin Energy Denison 3D Seismic Survey (Woodman Environmental 2004). A summary of vegetation communities recorded during the seismic survey and correlating communities within the Dongara tenements is provided in Table 7.

Table 7: Vegetation Communities within the ARC Energy/Origin Energy Denison 3D Seismic Survey and the Dongara Project Area

Dongara Project Area	Denison 3D Seismic Survey	Comments
W1 Woodland of *Eucalyptus camaldulensis* over mixed shrubs dominated by *Acacia* spp. and Melaleuca spp. on sandy clay soils in valleys and floodplains	W8 Woodland of *Eucalyptus camaldulensis* and occasional *Melaleuca* spp. over tall shrubs dominated by *Chamelaucium uncinatum* and *Acacia rostellifera* on grey sand	Is part of a large wetland system predominantly on a block of private property surrounded by the Yardanogo Nature Reserve
W2 Low Woodland of *Melaleuca preissiana* and *Casuarina obesa* on clay soils in basins and floodplains	F1 Tall Forest of *Melaleuca preissiana* and occasional *Casuarina obesa* over herbs on winter wet sandy clay	Is part of a large wetland system predominantly on a block of private property surrounded by the Yardanogo Nature Reserve
W3 Low Woodland of *Eucalyptus erythrocorys* over Thicket to Low Heath dominated by *Acacia* spp. or *Melaleuca* spp. on sand over limestone on mid to upper slopes.	W2 Low Woodland dominated by *Eucalytpus erythrocorys* on shallow soils with limestone outcropping	A small representation of this community is found within the Yardanogo Nature Reserve
W6 Open Low Woodland to Heath of *Banksia attenuata* and *Banksia menziesii* over mixed myrtaceous and proteaceous shrubs on grey and brown sand on mid to upper slopes	W7 Open Low Woodland of *Banksia menziesii* over Heath dominated by *Banksia attentuata* and mixed proteaceous shrubs	Is found on the eastern margins of the Yardanogo Nature Reserve
T3 Thicket to Heath dominated by *Banksia hookeriana* and *Banksia attenuata* on yellow sand on mid to upper slopes	H6 Heath dominated by *Banksia hookeriana* on deep yellow sand	Is the predominant community found within the Yardanogo Nature Reserve
H3 Heath dominated by *Hakea polyanthema*, *Beaufortia elegens*, *Calothamnus blepharospermus* or *Eremaea beaufortioides* over Dwarf Scrub dominated by *Ecdeiocolea monostachya* on brown or yellow sand on lower to upper slopes	H11 Low Heath dominated by *Ecdeiocolea monostachya* and *Calothamnus blepharospermus* on yellow sand	A small representation of this community is found within the Yardanogo Nature Reserve

Beard (1976) comments that latertic heaths (as described by community H5) are very heterogenous and demonstrate increasing species richness moving south accompanying increases in rainfall. Lateritic heaths dominated by *Eremaea violaceae* or *Dryandra carlinoides* (H5) have been observed within the Coomallo Reserve, Tathra National Park, Badgingarra National Park and South Eneabba Reserve (Martinick and Associates 1989). Community H5 correlates with Association 379 by Shepard et al (2000, Table 1). It is estimated that 20% of this community is held within reserves and approximately 20% of pre-european extent remains.

Community W5 is characterised by *Eucalyptus todtiana* Open Low Woodland with occasional *Xylomelum angustifolium* and *Banksia* spp. and is located within the South Eneabba Reserve, Tathra National Park and to a lesser extent Reserve 29806. This community correlates with Association 378 as described by Shepard et al (2000, Table 1). It is estimated that approximately 21% of this association is held in reserves and approximately 62% of pre-european extent remains.

The woodlands in the project area associated with *Eucalyptus erythrocorys* (W3) in the presence of limestone are also found within the Lesueur National Park (CALM 1995).

Due to limited study of vegetation communities within the Dongara area and the variability of understorey species within structural communities it is difficult to assess local and regional significance. Detailed studies to be conducted by Woodman Environmental Consulting will provide additional understanding of the local and regional extent of communities found within the Dongara project area.

6.3 Potential Impacts of the Project

The exploration drilling for the Tiwest Dongara project has the potential to adversely impact flora and vegetation. These impacts are:

1. Disturbance of plant communities – Full clearing of vegetation will not be required along the proposed exploration drill lines as drill rigs and associated vehicles drive over existing low vegetation and avoid trees. Occasionally a rubber tyred loader will be used to flatten vegetation for vehicle access where it is too high or thick for light vehicles and drill rigs to drive over. Future mine development would require full clearing of plant communities.

2. Loss of significant flora species – There are a number of Rare and Priority Flora species and undescribed taxa that are potentially located within areas to be cleared.

3. Risk of fire –Vehicle movement and machinery operation has the potential to cause fires in the densely vegetated areas.

4. Negative impacts to Conservation values of Nature Reserves – Parts of the project area border the Yardanogo Nature Reserve and the introduction of weeds or plant diseases to areas bordering the Reserve, or ignition of a wildfire during drilling activities could impact the value of the Nature Reserve.

5. Potential introduction and spread of weeds and plant diseases such as *P. cinnamomi* by ground disturbance activities and vehicle traffic.

6. Indirect impacts – Ground disturbance activities and vehicle traffic may lead to the generation of dust and impacts to surface drainage patterns.

7 RECOMMENDATIONS

7.1 Recommendations for Exploration Drilling

The following recommendations are made based on the results of the flora, vegetation and dieback survey and are relevant to the proposed drilling program:

1. A Risk Management Plan should be developed to manage potential impacts of a proposed drill program on DRF Species, Priority and Undescribed Species and Communities of significance.

2. All precautions should be taken to prevent accidental fires. These include the use of spark arrestors on petrol engines and the provision of a fire tender during hot conditions.

3. All vehicles commencing work on the project should be weed free (i.e. clean and free of any dirt that could carry spores and seeds).

4. Areas deemed 'Unmappable' for *Phytophthora cinnamomi* infestations should be re-assessed in 12 months time due to recent burning.

5. Vehicles and machinery must be cleaned prior to entering the site at a 'Clean on Entry Point' to prevent the introduction of *P. cinnamomi*.

   Clean on Entry points will include:

   - a pad for inspecting and cleaning vehicles, plant and equipment. The pad is to be lined with either limestone (to a minimum depth of 20cm) or heavy-duty rubber matting (conveyor material) or other surface such as ramps constructed from wooden sleepers to allow equipment to be cleaned without resting in potentially contaminated mud. The pad is to be sloped away from uninfested native vegetation and runoff from washdowns is to be directed to a shallow earthen sump;
   - a stiff bristled brush and broom for brushing soil material from equipment under dry conditions;
   - a high pressure water washdown unit for use during wet conditions. Water for washdowns must be dosed with sodium hypochlorite to a minimum of 7 parts per million active chlorine; and
   - a Clean on Entry point sign.

   Vehicles, plant and equipment will stop on the inspection pad at each Clean on Entry point prior to travelling past the Clean on Entry point sign in the direction of hygiene and inspected for soil, soil slurry or vegetation material. Inspections will include tyres/wheels, undercarriage, belly plates, buckets and tracks of all equipment.

Should any of the mentioned materials be present, the equipment must be cleaned and the material removed. Dry conditions will require a brushdown to remove dirt clods or vegetation. Dust does not have to be cleaned from the vehicle. Wet conditions with mud present will require a washdown with high pressure water.

7.2 Recommendations for Future Mining

The following recommendations are made based on the results of the flora, vegetation and dieback survey and are relevant for future works within the Dongara project area:

1. Further definition of the local and regional extent of DRF species *Paracaleana dixonii, Caladenia wanosa* and *Calectasia cyanea*, in addition to 4 undescribed *Stylidium* species will be required.

2: The regional conservation significance of all plant communities (mapped by Woodman Environmental Consulting) to be impacted by the proposed mining operations requires further investigation to confirm the representation of plant communities in the conservation estate. This should be achieved through floristic studies both within the mining areas and in the local region.

3: The Dongara leases should be fenced or access restricted in some way prior to the commencement of mine development to ensure hygiene precautions are uniform across the site and the potential for third parties to introduce *P. cinnamomi* is reduced. A hygiene plan should then be developed for operations to ensure the uninfested status of the leases.

4. Further investigations of the potential impacts of mining on surface and subsurface hydrology and associated impacts on flora and vegetation are required.

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LEGEND

Forests

- F1: Low Forest of *Melaleuca rhaphiophylla* over Open Dwarf Scrub on sandy clay in drainage lines

Woodlands

- W1: Woodland of *Eucalyptus camaldulensis* over mixed shrubs dominated by *Acacia* spp. and *Melaleuca* spp. on sandy clay soils in valleys and floodplains
- W2: Low Woodland of *Melaleuca preissiana* and *Casuarina obesa* on clay soils in basins and floodplains
- W3: Low Woodland of *Eucalyptus erythrocorys* over Thicket to Low Heath dominated by *Acacia* spp. or *Melaleuca* spp. on sand over limestone on mid to upper slopes
- W3d: Degraded W3 community
- W4: Low Woodland dominated by *Banksia prionotes* on yellow sand with occasional limestone outcropping on upper slopes and ridges
- W5: Open Low Woodland of *Eucalyptus todtiana* with occasional *Xylomelum angustifolium* and *Banksia* spp. over Open Shrubs to Heath dominated by myrtaceous and proteaceous species on grey sand on mid to upper slopes
- W5a: Open Low Woodland of *Eucalyptus todtiana* over Open Low Scrub dominated by *Calothamnus quadrifidus* on grey brown sand in creeklines
- W6: Open Low Woodland to Heath of *Banksia attenuata* and *Banksia menziesii* over mixed myrtaceous and proteaceous shrubs on grey and brown sand on mid to upper slopes
- W7: Open Low Woodland of *Eucalyptus todtiana* and *Actinostrobus pyramidalis* over Heath of mixed shrubs on grey brown sand on lower tamid slopes and swales

Scrub

- S1: Low Scrub dominated by *Jacksonia hakeoides, Melaleuca systena, Acacia blakelyi* and *Hakea trifurcata* on yellow sand over limestoneon mid slopes

Thickets

- T1: Thicket dominated by *Actinostrobus pyramidalis* on clayey soils in basins and lower slopes
- T1d: Degraded T1 community
- T2: Thicket dominated by *Allocasuarina campestris* and *Acacia* spp. on sandy clay on lower slopes, gullies and basins
- T3: Thicket to Heath dominated by *Banksia hookeriana* and *Banksia attenuata* on yellow sand on mid to upper slopes
- T4: Dense Thicket of *Melaleuca huegelii* over Open Dwarf Scrub on sandy clay over limestone on lower slopes

Heaths

- H1: Heath dominated by *Melaleuca systena* in pans with impeded drainage
- H2: Heath dominated by *Banksia leptophylla, Calothamnus hirsutus* and myrtaceous species in pans with impeded drainage
- H3: Heath dominated by *Hakea polyanthema, Beaufortia elegens, Calothamnus blepharospermus* or *Eremaea beaufortioides* over Dwarf Scrub dominated by *Ecdeiocolea monostachya* on brown or yellow sand on lower to upper slopes
- H4: Heath dominated by *Acacia* spp. *Calothamnus quadrifidus, Hakea lisscarpha* and *Melaleuca leuropoma* with emergent *Eucalyptus* spp. on grey sand on lower slopes
- H5: Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes
- H5d: Degraded H5 community

Disturbed Areas

- Cl: Cleared area

Rare and Priority Species

All:	*Acacia latipes* subsp. *ilicina*	P3
Av:	*Acacia vittata*	P2
Be:	*Banksia elegans*	P4
Bs:	*Banksia scabrella*	P4
Bw:	*Boronia* sp. Walkaway (A.S. George 11249)	P3
Ca:	*Comesperma acerosum*	P3
Cc:	*Calytrix chrysantha*	P3
Cee:	*Calytrix ecalycata* subsp. *ecalycata*	P3
Cen:	*Calytrix eneabbensis*	P3
Cs:	*Calytrix superba*	P3
Cw:	*Caladenia wanosa*	DRF
Ds:	*Darwinia sanguinea*	P4
Ea:	*Eremaea acanthifolia*	P2
Ema:	*Eucalyptus macrocarpa* subsp. *elachantha*	P4
Emp:	*Eucalyptus macrocarpa* x *pyriformis*	P3
Ez:	*Eucalyptus zopherophloia*	P4
Ga:	*Guichenotia alba*	P3
Gc:	*Gastrolobium callistachys*	P4
Ge:	*Grevillea erinacea*	P3
Gq:	*Guichenotia quasicalva*	P2
Ha:	*Hopkinsia anoectocolea*	P3
Hc:	*Homalocalyx chapmanii*	P1
He:	*Hemiandra* sp. Eneabba (H. Demarz 3687)	P1
H?e:	*Hemiandra* sp. ?Eneabba (H. Demarz 3687)	P1
Hg:	*Hypocalymma gardneri*	P2
Hp:	*Hakea polyanthema*	P3
Hs:	*Hemigenia saligna*	P3
Ht:	*Hypocalymma tetrapterum*	P3
It:	*Isopogon triderx*	P3
Lo:	*Lasiopetalum ogilvieanum*	P1
MsE:	*Mesomelaena stygia* subsp. *deflexa*	P1
Os:	*Olax scalariformis*	P3
Pd:	*Paracaleana dixonii*	DRF
Pf:	*Persoonia filiformis*	P2
Pr:	*Persoonia rudis*	P3
Sa:	*Stachystemon axillaris*	P4
STa:	*Synaphea* ?*aephynsa*	P3
Sae:	*Synaphea aephynsa*	P3
Scn:	*Stylidium carnosum* subsp. Narrow leaves (J.A. Wege 490)	Under revision
Sd:	*Stawellia dimorphantha*	DRF
Sdp:	*Stylidium diuroides* subsp. *paucifoliatum*	P4
Sdr:	*Stylidium drummondianum*	P3
Se:	*Schoenus* sp. Eneabba (F. Obbens & C. Godden 1154)	P1
Sg:	*Schoenus griffinianus*	P2
Ss:	*Synaphea oulopha*	P1
Sp:	*Stylidium pseudocaespitosum*	P2
Ss1:	*Stylidium* sp. 1	Undescribed
Ss2:	*Stylidium* sp. 2	Undescribed
Ss3:	*Stylidium* sp. 3	Undescribed
Ssp:	*Synaphea sparsiflora*	P2
St:	*Stylidium torticarpum*	P3
Te:	*Tricoryne* sp. Eneabba (E.A Griffin 1200)	P2
Tg:	*Thysanotus glaucus*	P4
Tp:	*Triglochin protuberans*	P3
Vdo:	*Verticordia dasystylis* subsp. *oestopoia*	P1
Vb:	*Verticordia blepharophylla*	P2
V?b:	*Verticordia ?blepharophylla*	P2
Vlt:	*Verticordia luteola* var. *luteola*	P3
Vlr:	*Verticordia luteola* var. *rosea*	P1

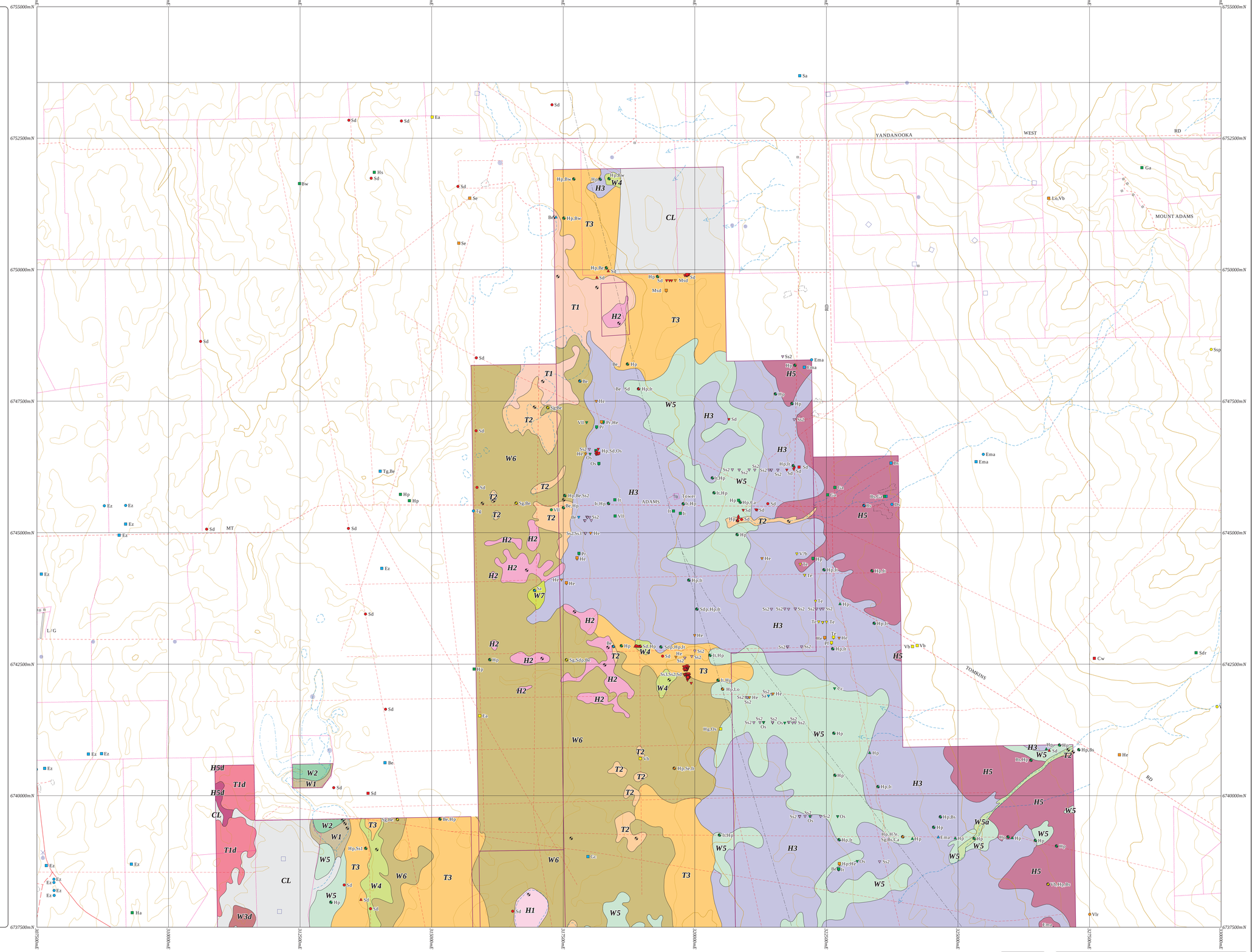
Recording Site

Rare & Priority Species

Priority	DEC	Herbarium	WEC	Western Botanical	TEC
Rare	●	■	▲	▼	★
1	●	■	▲	▼	
2	●	■	▲	▼	
3	●	■	▲	▼	
4	●	■	▲	▼	
Undescribed	●	■	▲	▼	

Proposed Drilling 2007

Proposed Access 2007



0 500m

Scale
MGA94 (Zone 50)
WEC Ref WPC06-22

woodmanenvironmentalconsulting

DONGARA PROJECT AREA - E70/2263, E70/2347 & E70/1592

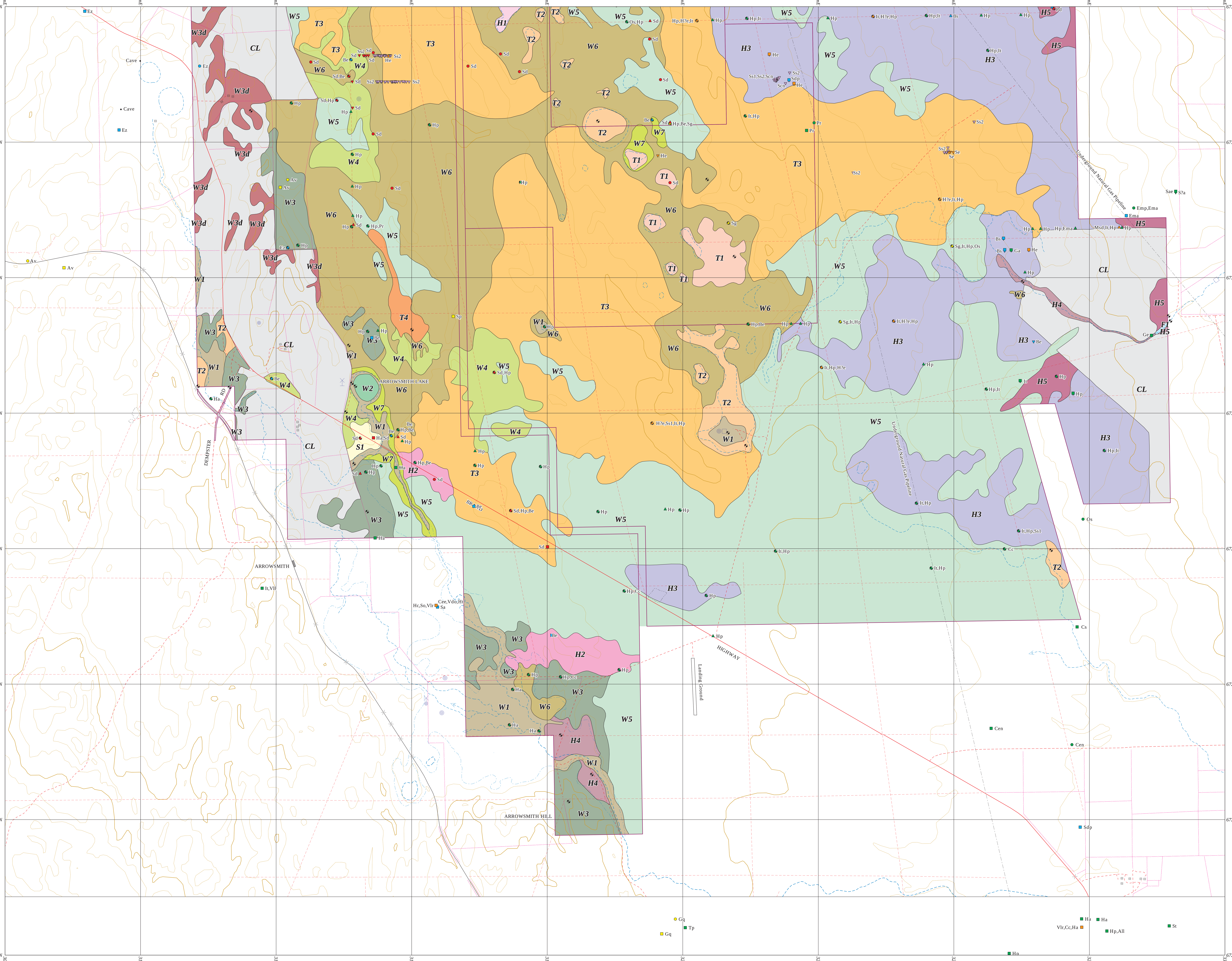
VEGETATION

Figure 1.1

Author: D. Woodman

Sheet 1 of 2

Drawn: CAD Resources - Tel 9246 3242 - URL www.cadresources.com.au - Jun 2007 - A0 - Rev. 0 - CAD Ref g1411_v01.dgn



LEGEND

Forests

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W5: Open Low Woodland of *Eucalyptus todtiana* with occasional *Xylomelum angustifolium* and *Banksia* spp. over Open Shrubs to Heath dominated by myrtaceous and proteaceous species on grey sand on mid to upper slopes
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W7: Open Low Woodland of *Eucalyptus todtiana* and *Actinostrobus pyramidalis* over Heath of mixed shrubs on grey brown sand on lower to mid slopes and swales

Scrub

S1: Low Scrub dominated by *Jacksonia hakeoides, Melaleuca systena, Acacia blakelyi* and *Hakea trifurcata* on yellow sand over limestone on mid slopes

Thickets

T1: Thicket dominated by *Actinostrobus pyramidalis* on clayey soils in basins and lower slopes
T1d: Degraded T1 community
T2: Thicket dominated by *Allocasuarina campestris* and *Acacia* spp. on sandy clay on lower slopes, gullies and basins
T3: Thicket to Heath dominated by *Banksia hookeriana* and *Banksia attenuata* on yellow sand on mid to upper slopes
T4: Dense Thicket of *Melaleuca huegelii* over Open Dwarf Scrub on sandy clay over limestone on lower slopes

Heaths

H1: Heath dominated by *Melaleuca systena* in pans with impeded drainage
H2: Heath dominated by *Banksia leptophylla, Calothamnus hirsutus* and myrtaceous species in pans with impeded drainage
H3: Heath dominated by *Hakea polyanthema, Beaufortia elegens, Calothamnus blepharospermus* or *Eremaea beaufortioides* over Dwarf Scrub dominated by *Ecdeiocolea monostachya* on brown or yellow sand on lower to upper slopes
H4: Heath dominated by *Acacia* spp. *Calothamnus quadrifidus, Hakea lissocarpha* and *Melaleuca leuropoma* with emergent *Eucalyptus* spp. on grey sand on lower slopes
H5: Heath to Low Heath dominated by *Dryandra* spp. and *Melaleuca aspalathoides* on sand over laterite on lower to mid slopes
H5d: Degraded H5 community

Disturbed Areas

Cl: Cleared area

Rare and Priority Species

All:	*Acacia latipes* subsp. *licina*	P3
Av:	*Acacia vittata*	P2
Be:	*Banksia elegans*	P4
Bs:	*Banksia scabrella*	P4
Bw:	*Baeckea* sp. Walkaway (A.S. George 11249)	P3
Ca:	*Comesperma acerosum*	P3
Cc:	*Calytrix chrysantha*	P3
Cee:	*Calytrix ecalycata* subsp. *ecalycata*	P3
Cen:	*Calytrix eneabbensis*	P3
Cs:	*Calytrix superba*	P3
Cw:	*Caladenia wanosa*	DRF
Ds:	*Darwinia sanguinea*	P4
Ea:	*Eremaea acutifolia*	P2
Ema:	*Eucalyptus macrocarpa* subsp. *elachantha*	P4
Emp:	*Eucalyptus macrocarpa* x *pyriformis*	P3
Ez:	*Eucalyptus zopherophloia*	P4
Ga:	*Guichenotia alba*	P3
Gc:	*Gastrolobium callistachys*	P4
Ge:	*Grevillea erinacea*	P3
Gq:	*Guichenotia quasicalva*	P2
Ha:	*Hopkinsia anoectocolea*	P3
Hc:	*Homalocalyx chapmanii*	P1
He:	*Hemiandra* sp. Eneabba (H. Demarz 3687)	P1
H?e:	*Hemiandra* sp. ?Eneabba (H. Demarz 3687)	P1
Hg:	*Hypocalymma gardneri*	P2
Hp:	*Hakea polyanthema*	P3
Hs:	*Hemigenia saligna*	P3
Ht:	*Hypocalymma tetrapterum*	P3
It:	*Isopogon tridens*	P3
Lo:	*Lasiopetalum ogilvieanum*	P1
Msd:	*Mesomelaena stygia* subsp. *deflexa*	P1
Os:	*Olax scalariformis*	P3
Pd:	*Paracaleana dixonii*	DRF
Pf:	*Persoonia filiformis*	P2
Pr:	*Persoonia rudis*	P3
Sa:	*Stachystemon axillaris*	P4
S?a:	*Synaphea ?aephynsa*	P3
Sae:	*Synaphea aephynsa*	P3
Scn:	*Stylidium carnosum* subsp. Narrow leaves (J.A. Wege 490)	Under revision
Sd:	*Stawellia dimorphantha*	DRF
Sdp:	*Stylidium diuroides* subsp. *paucifoliatum*	P4
Sdr:	*Stylidium drummondianum*	P3
Se:	*Schoenus* sp. Eneabba (F. Obbens & C. Godden I154)	P1
Sg:	*Schoenus griffinianus*	P2
So:	*Synaphea oulopha*	P1
Sp:	*Stylidium pseudocaespitosum*	P2
Ss1:	*Stylidium* sp. 1	Undescribed
Ss2:	*Stylidium* sp. 2	Undescribed
Ss3:	*Stylidium* sp. 3	Undescribed
Ssp:	*Synaphea sparsiflora*	P2
St:	*Stylidium torticarpum*	P3
Te:	*Tricoryne* sp. Eneabba (E.A Griffin 1200)	P2
Tg:	*Thysanotus glaucus*	P4
Tp:	*Triglochin protuberans*	P3
Vdo:	*Verticordia dasystylis* subsp. *oestopoia*	P1
Vb:	*Verticordia blepharophylla*	P2
V?b:	*Verticordia ?blepharophylla*	P2
Vll:	*Verticordia luteola* var. *luteola*	P3
Vlr:	*Verticordia luteola* var. *rosea*	P1

Recording Site

Rare & Priority Species

Priority	DEC	Herbarium	WEC	Western Botanical	TEC
Rare	●	■	▲	▼	★
1	●	■	▲	▼	
2	●	■	▲	▼	
3	●	■	▲	▼	
4	●	■	▲	▼	
Undescribed	●	■	▲	▼	

Proposed Drilling 2007
Proposed Access 2007

Scale
MGA94 (Zone 50)
WEC Ref WPC06-22

woodmanenvironmentalconsulting

DONGARA PROJECT AREA - E70/2263, E70/2347 & E70/1592

VEGETATION

Figure 1.2

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