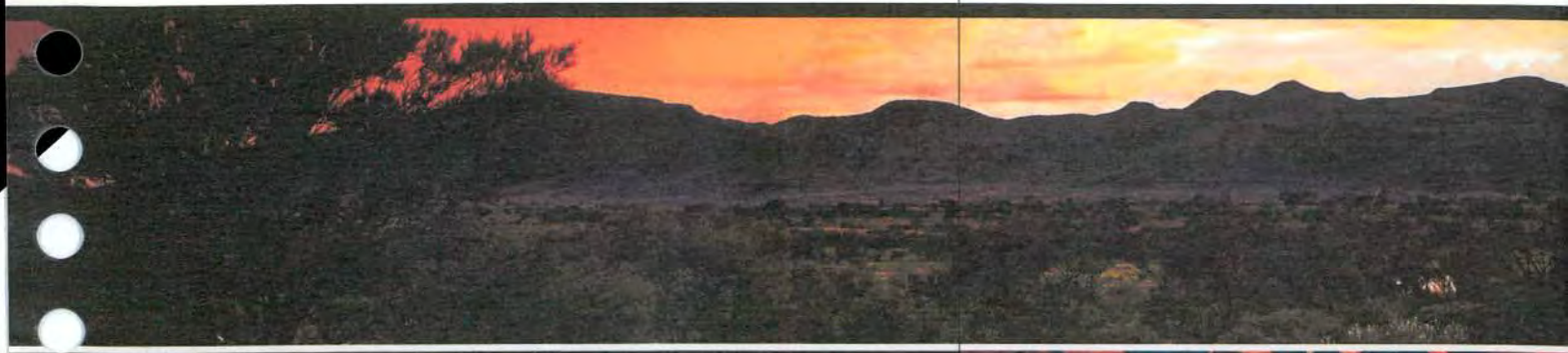
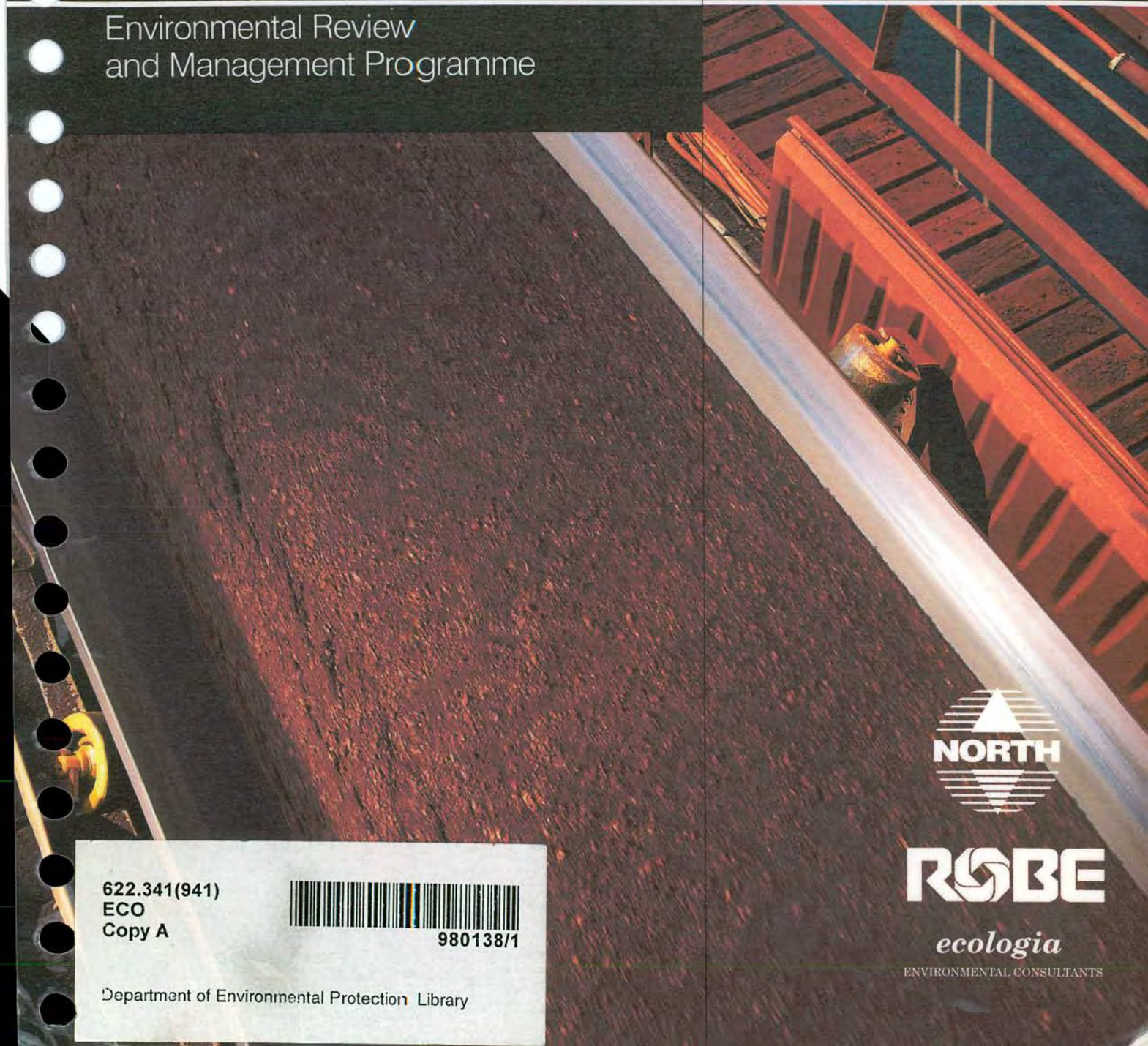
West Angelas Project



Environmental Review and Management Programme



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ROBE RIVER MINING CO. PTY. LTD.

WEST ANGELAS IRON ORE PROJECT

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

MARCH 1998

Prepared by

ecologia

ENVIRONMENTAL CONSULTANTS

ROBE RIVER MINING CO PTY LTD

West Angelas Environmental Review & Management Programme

How To Make Public Submissions

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Environmental Review and Management Program (ERMP) proposes the development of the West Angelas Iron Ore Project, railway and Cape Lambert port upgrade. In accordance with the Environmental Protection Act 1986 a PER has been prepared which describes this proposal and its likely effect on the environment. The ERMP is available for public review for eight (8) weeks from Monday 16 March 1998 closing on Monday 11 May 1998.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approaches. It is useful if you indicate any submissions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the *Freedom of Information Act*, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the work for an individual or group, as well as while increasing the pool of ideas and information. If you form a small group (up to 10 people) please indicate the names of all participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the ERMP or with the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the ERMP:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that the issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the ERMP;
- if you discuss different sections of the ERMP, keep them distinct and separate, so there is no confusion about which section you are considering;
- attach any factual information you want to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- Your name;
- address;
- date; and
- whether you want your submission to be confidential.

THE CLOSING DATE FOR SUBMISSIONS IS: **Monday 11 May 1998**

Submissions should be addressed to: Attention: Mr Murray Hogarth

Environmental Protection Authority
Westralia Square
141 St Georges Terrace
PERTH WA 6000

Environmental Protection Authority
PO Box K822
PERTH WA 6842

EXECUTIVE SUMMARY

Robe River Mining Co. Pty. Ltd. (Robe) is proposing to mine Deposits A and B at West Angelas, and any economic ore proven from Deposits C - H. The two main deposits, termed 'A' and 'B', were found to be the key areas of mineralisation, having a measured iron resource of 458 and 236 Mt respectively. Transport of ore requires the construction of a rail link between the proposed West Angelas mine and Cape Lambert, and an associated increase in the capacity of the port facilities at Cape Lambert to enable the shipping of West Angelas ore. The project is being designed to have a mining and production capacity of 20 Mtpa, with a construction phase of about 30 months and an expected project life of 27 - 30 years.

The mining at West Angelas will be conducted using conventional open pit methods. Mine planning will endeavour to maximise placement of overburden inside the mine pit limits as extraction of ore proceeds throughout the mine life, thus minimising further surface disturbance.

A total of 12 - 15 % of the mining at Deposit A would be below the water table. However, due to the impermeable nature of the geological strata, the volume of de-watering required is expected to be low. Skid mounted sump pumps are proposed to be utilised for dewatering. Rainfall which collects in the bottom of the pit will be pumped out. Dewatering water would be mostly used on-site, but in exceptional circumstances such as heavy rainfall events it would be released to drainage channels. The mined material in this region is oxidised, so acid-mine drainage is not expected to be an issue.

Upon completion of mining areas, overburden wastes will be used to cover parts of the mine pit below the natural water table.

The products from the plant will be <37.5 mm lump and <6.3 mm fines material, which will be stockpiled separately prior to loading onto trains for transport to Cape Lambert. Stockpile capacity will be sufficient for three days reserves.

Rail operations are expected to be a maximum of 22 trains per week, each train composed of 170 cars. A Long-Airdox bulk loading chute and automatic control system will be used for train loading. A single bin loadout system will be adopted for loading ore cars with the ore.

Support infrastructure for mining will include a private access road to the West Angelas minesite off Great Northern Highway, a heavy vehicle and plant maintenance workshop and warehouse, offices, radio facilities, accommodation village, an airstrip and an explosives storage facility constructed according to mining regulations.

Water requirements for the project are estimated to be 19 ML/day which will be supplied from the Turee Creek B borefield. Water would be pumped to the mine area in an above ground steel pipeline. An access track would be constructed alongside the pipeline.

Fuel will be delivered to the West Angelas mining area by trains from Cape Lambert and stored in bunded bulk fuel tanks.

Depending on current negotiations, power for the minesite will come from either:

(i) a mine site gas fired power station; or

(ii) an overhead transmission line drawing from that to be built by Pilbara Energy Pty Ltd (PEPL) to serve BHP's Mining Area C and other future projects in the area.

For construction of a gas fired power station at West Angelas, a low pressure gas pipeline would be laid underground to connect to the Goldfields Gas Transmission natural gas pipeline at the Boonanchi Wells valve station located approximately 55 km south-east of West Angelas. At this stage, the gas fired power station and pipeline is the preferred option.

With increased export volumes from West Angelas ore shipping is expected to increase from 185 to 397 ships per year. To allow for the movement of West Angelas product through Cape Lambert, the port facility will require an expansion which is expected to include a new shiploader, a 250 m extension to the existing wharf and associated dredging on both sides of the wharf, deepening and widening of the departure channel for a distance of over 1 km seawards from the new wharf head to accommodate > 230,000 DWT vessels, and some modifications to existing facilities. Dredging volumes are estimated to be about 590,000 m^3.

The structures proposed to be constructed on the land portion of the Cape Lambert facility, as part of the West Angelas project, are:

- rotary ore car dumper;
- a product stockpile pad which requires the construction of a new sea wall and reclamation of approximately 44 hectares of land;
- a tertiary screening facility; and
- new rail and plant control and maintenance facilities.

During construction up to 1200 people including up to 450 people in railway construction camps may need to be accommodated. During operation of the West Angelas mine, approximately 180 persons will be working on-site. Accommodation for employees will be provided in a village to be constructed at the base of the West Angelas. For the railway it is proposed that construction camps would be established at about 100 km intervals.

ALTERNATIVES CONSIDERED

Alternatives were investigated for the wharf extension and ore stockpile area at Cape Lambert.

Preliminary investigations indicated that there was little groundwater potential close to the West Angelas deposits. Six potential locations were considered on the basis of potential groundwater yield, cost of development, environmental constraints and logistical constraints with the Turee Creek (B) location being the one selected.

Railway Route Selection - The option of dual tracking Hamersely Iron's Central Pilbara and Paraburdoo - Dampier railways has been extensively considered in the route evaluation process. In four sections of this route the constraints imposed by topography, substrate type, surface drainage hydrology and the existing HI railway design dictate that to minimise environmental impact and achieve worlds best practice alternative routes have been selected in each of these sections.

The Selected Rail Alignment

The selected rail route commences by passing to the north of West Angelas Hill, looping slightly west around Coondawanna Flats then strikes north west towards Packsaddle. The route then heads west-north-west to meet the rail formation constructed by Hamersley Iron (HI) between Marandoo and Homestead Junction.

From this point, the general route parallels the HI formation within the excised transport corridor which traverses Karijini National Park. The proposed line will dual track the existing HI formation initially on the southern side, crossing the HI line by an overpass located approximately 20 km north-west of the Juna Downs. The line will then dual track the existing HI Marandoo line to the western boundary of the National Park. The Turee Creek system is crossed between the overpass and Marandoo.

Throughout the Karijini section the proposed route is generally within 100-200 m of the HI alignment except where it is necessary to divert around miscellaneous HI leases where separations of up to 600 m occur.

West of Mt Stevenson the preferred rail route leaves the Marandoo spur line and strikes north on the "Four Corners Bore" route option. This route passes to the north of Four Corners Bore, before deviating north-west to meet up with the Hamersley Iron Paraburdoo - Dampier Railway approximately 7 km east of Satellite Spring.

The route then parallels the Paraburdoo - Dampier Railway to the north for approximately 60 km. Most of this section parallels the HI alignment within 100-200m except for about 40 km at the northern end (near Mt Leal) where the rail is located between 400 and 800 m from the HI alignment.

The Mt Leal section diverges from the HI alignment by up to eight kilometres, and for 10 km runs parallel at this distance of separation.

Approximately 2.5 km north of Barowanna Hill, the preferred route heads north onto the "Western" route which roughly parallels the existing Hamersley Iron Railway to the east. The route merges into the Robe Pannawonica - Cape Lambert Railway at a point approximately 3 km north of the Robe River and Hamersley

Iron railway's intersection.

The Western Route maintains a 100 m separation for the first 13 km and then diverges up to a maximum of five kilometres for the next seven kilometres. For the next 10 km the distance between the proposed route and the HI track varies between 400 to 1 200 m. The last three kilometres run parallel to the existing Robe railway at a distance of approximately 500 m.

Within the Millstream - Chichester National Park it is anticipated the rail line will be located within a Miscellaneous Licence granted through Robe's State Agreement Act. Use of the licence will avoid the requirement for excision of segments of the National Park for the rail alignment and will not result in the extinguishment of Native Title for this land use.

HERITAGE

Aboriginal heritage surveys, both archaeological and ethnographic, have been conducted in the West Angelas project area, and a number of Aboriginal Heritage sites have been recorded. Community consultation with native title claimants has also been undertaken. No significant Aboriginal sites will be impacted by the project. No non-aboriginal sites of heritage value will be affected by the project.

PROJECT IMPACTS AND MANAGEMENT

A summary table which responds to the EPA's guidelines follows. The environmental factors considered under biophysical generally only consider direct impacts on the biological and physical environment. Biological impacts which arise from contaminants entering the environment and potential impacts relating to changes to water quality are generally considered under the Pollution Management heading.

ENVIRONMENTAL MANAGEMENT SYSTEMS AND REPORTING

Robe has in place an integrated Health, Safety and Environmental Management System which encompasses the same general framework as ISO 14000 and BS 7750 but follows the DuPont line which focuses more on peoples behaviours than paperwork.

Robe's parent company, North Limited, undertakes annual Environment, Safety and Health reporting. In 1997 the annual report included external reviews of all operations, assessment by a steering committee which included independent experts and recommendations for action to improve performance. These are currently being implemented.

Robe has also committed to the Australian Minerals Industry Code for Environmental Management, which has a strong emphasis on environmental performance accountability and community consultation, and which requires signatories to report publicly on environmental performance and implementation of the Code.

Clause 7AC of the Iron Ore (Robe River) Agreement Act requires Robe to carry out a continual programme of investigation, research and monitoring to ascertain the effectiveness of the measures it is taking pursuant to the protection and management of the environment. Robe must prepare annual and detailed triennial reports to this effect, and each triennial report needs to contain a programme of environmental protection and management proposals for the following three years.

Robe wishes to link its current environmental management reporting with any reporting requirements which may be required by the Minister for the Environment for this proposal.

Table ES.1: Summary of key characteristics associated with the proposal.

Aspect	Proposal characteristic
Mine	
Ore mining rate	20 Mtpa
Total estimated production (Deposits A & B)	~ 450 Mt
Life of project (Deposits A to H)	29 years
Mine pit area	
• Deposit A	460 ha
• Deposit B	335 ha
Maximum depth of pit	
• Deposit A	250 m
• Deposit B	180 m
Area of Overburden Storage	
• Deposit A	850 ha
• Deposit B	600 ha
Dewatering requirements	Minor except after heavy rainfall
Dewatering discharge	Normally to process plant and dust control
Water supply source	Turee Creek B
Water supply requirements	
• Construction	2 ML/day
• Operation	4 ML/day
• Incorporating desliming plant	16 ML/day
Power source	
• Gas pipeline option	46 km
• Overhead powerline option	50.5 km
Transport infrastructure	
• Airstrip	2,300 m runway
• Water pipeline	30 km above ground
Location of mine accommodation village	12 km north-west of mine
Railway	
Length of railway	340 km
Train Movements	22 trains per week (170 cars per train)
Port	340 km
Ship loading	15-20 Mt/a
Reclamation for port stockpile	44.4 ha
Wharf extension	250 m
Workforce (entire project)	
• Construction	1 200
• Operation	450

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
BIOPHYSICAL							
Vegetation Communities	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.	Baseline studies to identify existing vegetation communities. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and railway construction. Propose measures to manage impacts.	Minesite is uncleared. Conservation value of the vegetation very high. Railway route uncleared, but disturbance has occurred where rail route is parallel to Hamersley Iron's railway. Conservation value of vegetation variable - considered to be high within or adjacent to National Park. Vegetation at Cape Lambert is locally or not significant.	Robe's Pannawonica operations require: progressive assessment of vegetation significance; that measures be put in place to restrict clearing to planned areas; storage and re-use of topsoil, and rehabilitation as facilities are decommissioned. Weed management program is also in place. Measures to prevent fires are in place.	One major (Trudgen & Associates) and three minor vegetation and flora survey undertaken for this ERMP. Otherwise mapping a 1:1 000 000 scale or site specific surveys only.	Clearing of approximately 600 ha for mine camps and infrastructure, 2 100 ha for Deposits A & B in the first 5-10 years of operation, then the remaining deposits. Clearing along the railway alignment, and potential disruption of surface sheet flow to mulga.	Current management practices will be transferred to the West Angelas Project. Drainage design along the railway will reflect or improve on existing standard set by Hamersley Iron's railway, and where it is not located near Hamersly's railway ensure sheet flow is maintained to mulga communities.
Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Baseline studies to identify any Declared Rare and/or Priority Flora. Assessment of potential impacts (direct and indirect) on Declared Rare and Priority Flora as a result of mining activities and railway construction. Propose measures to manage impacts.	West Angelas Survey Area has 16 species of conservation interest Along the railway alignment the number of species of conservation interest and flora sites of interest respectively are Coondawana West 44 & 3; Marandoo 43 & 4; Four Corners Bore, 10 & 2; Mt Leal 19 & 5; Hamersley Parallel (Western) 19 & 2.	As described for Vegetation Communities above.	As above. Most existing survey work is project specific, rather than species specific.	As above.	As above. Robe will comply with the *Wildlife Conservation Act 1950* and consider propagation of species of conservation interest in revegetation works.
Terrestrial Fauna	Maintain the abundance, species diversity and geographical distribution of terrestrial fauna.	Baseline studies to identify existing terrestrial fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Propose measures to manage impacts.	Area is remote. Impacts from pastoral use only.	As described for Vegetation Communities above.	Fauna Assessment Survey (*ecologia* Environmental Consultants, 1997) and Biological Assessment Survey (Integrated Environmental Services, 1978).	Loss of habitat, trapping of animals in pits and holes, increased feral fauna populations.	As per Vegetation Communities factor above - existing management procedures consider conservation value for fauna. Borrow pits will be contoured & drill holes capped. Waste/ food disposal will occur in accordance with Code of Practice for Rural Landfills. Little or no change to current status of terrestrial fauna.
Specially Protected (Threatened) Fauna	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Baseline studies to identify existing threatened fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Propose measures to manage impacts.	Species protected by the Wildlife Conservation Act, 1950 which occur in the project area include: Grey Honeyeater, Ghost Bat, Grey Falcon, Peregrine Falcon & Spotted Nightjar. Species protected by international migratory bird agreements include some shorebirds and the Fork-tailed Swift.	N/A	Fauna Assessment Survey (*ecologia* Environmental Consultants, 1997) and Biological Assessment Survey (Integrated Environmental Services, 1978)	Loss of mulga and disturbance. Ghost Bats may be affected.	Minimise loss of mulga habitat (see Vegetation Communities factor above). To protect Ghost Bats maintain 100 m buffer zone, no barbed wire unless statutory requirement and monitor populations. Little change to the current status of specially protected fauna.

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
Marine Flora, Marine Fauna and Specially Protected (Threatened) Marine Fauna	Maintain the ecological function, abundance, species diversity and geographic distribution of marine flora, including mangroves. Maintain the abundance, species diversity and geographic distribution of marine fauna. Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Baseline studies to identify existing marine flora, including mangroves, existing marine fauna, and existing threatened marine fauna around the proposed wharf extensions at Cape Lambert. Assessment of the potential impacts (direct and indirect) on marine flora including mangroves, fauna and on threatened marine fauna as a result of upgrading of the Cape Lambert facilities. Propose measures to manage impacts.	Cape Lambert includes existing spoil grounds which have rehabilitated to match the surrounding habitat. Various marine habitats with locally significant coral and mangroves on the western side and generally common/low conservation value habitat types on the eastern side. Ten to twelve small mangrove trees on the eastern side. Shorebird habitat on both sides of the Cape.	Refer to pollution management environmental factors below	Marine Environmental Impact Assessment (*ecologia*, 1997)	Minor loss of shorebird habitat from extension of stockpile area, short-term impacts from turbidity during dredging and seawall construction.	Construction of the seawall prior to backfilling to minimise turbidity. Preparation and implementation of a Dredging Management Plan. Small area of shorebird habitat loss. No long-term impacts on offshore marine habitat.
Watercourses	Maintain the integrity, functions and environmental values of drainage systems.	Baseline studies to identify watercourses, and types of surface water flow throughout the areas to be affected by the proposal. Baseline studies of wetlands throughout the areas to be affected by the proposal. Assessment of the potential impacts on surface water flow rates, drainage patterns, sediment transport, and wetlands, as a result of mining activities and railway construction. Propose measures to manage impacts.	Watercourses with large catchments cross some of the deposits to be mined. The railway crosses a range of watercourse types from major rivers to minor creeks. There are no watercourses at Cape Lambert.	Hamersley Iron's Railway has set the design/ management standard where Robe's railway runs in parallel.	Refer Figure 5.5 of this ERMP (prepared by Streamtec Consultants, 1997)	Changes in streamflow volumes from watercourse diversions around mine deposits. Along the railway, upstream ponding and downstream scouring if culverts not correctly designed.	Drainage diversion management plans will be prepared prior to commencement of mining operations for each deposit. Where the railway alignment parallels existing railways, Robe will duplicate the existing standard (i.e. size and capacity) and type of drainage structure; otherwise a 1:50 Average Recurrence Interval for storm events design criteria will be used.
Groundwater	Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	Detail of water requirements for the mining, processing, and other associated operations (including dewatering). Assessment of the implications this may have on regional groundwater. Propose measures to manage impacts.	Expected water requirements 17ML per day. The groundwater which flows through the potential water supply source may discharge into gorges in Karijini National Park. At the minesite the aquifer has a low hydraulic conductivity. At the borefield and minesite the watertable is well below the surface.	N/A	Groundwater resource assessment (Woodward Clyde, 1997)	About 15% of orebody is below the watertable, but the discharge of groundwater is expected to be minimal. Groundwater extraction from the borefield may extend into Karijini National Park after about 30 years.	The mine pit will be backfilled to above the watertable. Both the short-term and long term impacts will not be significant. An environmental management plan to monitor regional groundwater drawdown will be prepared for the borefield.

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
Landform	Establish stable, sustainable landform consistent with surroundings.	Assessment of potential impacts of the proposal, including the mine, railway, and port, on existing landforms. Detail of measures proposed to rehabilitate the impacted areas to an acceptable standard which will integrate the post mining landform with the surrounding environment. Assessment of potential impacts on visual amenity due to the development of the mine site and infrastructure associated with the mine site. Propose measures to manage impacts.	Landform characteristics such as slope vary significantly both at the minesite and along the railway line.	N/A	N/A	Mining pit and overburden dumps will remain after mining. Railway reverts to Government of Western Australia. Minimal impact on landforms at Cape Lambert.	Compliance with Department of Minerals and Energy guidelines on overburden dumps which include landform as a consideration. Stable post-mining landforms will remain. Location of the railway close to Hamersley's alignment within National Park minimises landform impacts. Rehabilitation will occur where appropriate (see Vegetation Communities factor above).
POLLUTION MANAGEMENT							
Particulates / Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards.	Assessment of potential increase in dust resulting from the construction and operation of the mine, infrastructure, and other associated activities. Assessment of potential impacts of increased dust on the amenity of surrounding land users from the construction and operation of the mine and associated activities. Proposed measures to manage impacts. Baseline studies to identify areas likely to contain asbestos and the form of this asbestos. Assessment of the potential risk to the public from mining operations and the decommissioned pits. Propose measures to manage risk.	Drilling logs have recorded asbestos in the Viveash Riebekite zone and mining may encroach on this horizon when developing the footwall to the final pit limits.	Dust and asbestos management procedures are in place at Pannawonica and Cape Lambert operations, and rail operations are managed so dust is not a problem during ore transport.	Drilling logs have been checked for occurrence of asbestos.	Increased levels of asbestos fibre or dust in the air.	Current management practices will be transferred to the West Angelas Project. Robe is reviewing dust impacts and monitoring requirements for dust entering the environment at Cape Lambert. The Department of Minerals and Energy Asbestos Management in Mining Guidelines will be complied with.
Greenhouse gases	Ensure that greenhouse gas emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise greenhouse gas discharge).	Detail of potential sources of greenhouse gases and estimates of the quantities of these gases produced annually.	Greenhouse gases would be generated from mining and transport-related operations.	Robe, as a member of the North group, is a participant in the Greenhouse Challenge program, which includes monitoring and emission minimisation procedures.	Monitoring through Greenhouse Challenge program.	Greenhouse gas emissions will occur from mining and transport-related operations.	Current management practices as detailed in the Greenhouse Challenge program, will result in a 10% overall reduction in Greenhouse Gas emissions to 2001.

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
Gaseous emissions *(SO_2)*	Ensure that SO_2 emissions meet the air quality standards and limits stated in the Kwinana EPP and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise SO_2 discharge).	Estimate quantities and concentrations of SO_2 emissions which will be generated by the project, in particular, the power station. Comparison of estimates with relevant standards and limits. Proposed measures to minimise SO_2 emissions.	Natural gas is used as a fuel source at Cape Lambert and so SO_2 emissions are negligible.	N/A	N/A	Nil - new power station at mine site will be powered by natural gas.	No increase in SO_2 emissions.
Gaseous emissions *(NO_x)*	Ensure that NOx emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise NOx discharge).	Estimate quantities and concentrations of NO_x emissions which will be generated by the project, in particular, the power station. Comparison of estimates with relevant standards and limits. Proposed measures to minimise NO_x emissions.	No existing power station near West Angelas. Cape Lambert power station has existing approvals for generation capacity required for this project.	N/A	Modelling undertaken for power station at minesite (Burns & Roe Worely, 1997)	Worst case analysis for minesite power station shows levels of NOx at nearest residential area well below health standards.	No management necessary, as adverse impacts are insignificant.
Groundwater quality	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Detail of water requirements for the mining, processing, and other associated operations. Detail of drainage, dewatering, and fate of water used/pumped. Detail of the possibility of acid mine drainage occurring, and potential impacts on the surrounding environment. Assessment of the implications this may have on local and regional groundwater quality. Propose measures to manage impacts.	Ore body is oxidised, so acid mine drainage is not an environmental issue. Railway passes through surface water catchment which feeds Millstream aquifer.	Pannawonica minesite and existing rail operations have measures in place to ensure potential contaminants are collected and disposed of appropriately.	Woodward Clyde (1997)	Increased usage of potential contaminants, and increased potential for contamination when mine operations below the water table. Potential for salinisation of groundwater through ongoing evaporation if mine pit not backfilled.	Current management practices will be transferred to West Angelas project. Mine pit will be backfilled to 2 m above the highest known water table. No significant change to groundwater quality is expected.
Surface water quality	Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Detail of water requirements for the mining, processing, and other associated operations. Detail of drainage, dewatering, and fate of water used/pumped. Detail of the possibility of acid mine drainage occurring, and potential impacts on the surrounding environment. Assessment of the implications this may have on local and regional surface/ground water quality. Proposed measures to manage impacts.	Existing railway passes through Harding Dam catchment. Episodic/ cyclonic nature of rainfall in the Pilbara leads to high sediment loads in surface waters when they flow.	Pannawonica minesite existing rail operations and Cape Lambert operations have measures in place to ensure potential contaminants are collected and disposed of appropriately. Mine waste dumps are constructed to minimise erosion/ sediment laden run-off.	N/A	Increased usage of potential contaminants.	Current management practices will be transferred to West Angelas project. Waste dumps will be constructed in accordance with Department of Minerals and Energy guidelines. No significant change to surface water quality is expected.

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
Marine water and sediment quality	Maintain or improve the quality of marine water consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993). Maintain or improve marine water and sediment quality consistent with Environmental Quality Objectives (EQO's) and Environmental Quality Criteria (EQC's) defined in the Southern Metropolitan Coastal Waters Study (1996).	Assessment of the potential impacts on marine water quality as a result of activities associated with the upgrade and operation of the Cape Lambert facility. Proposed measures to manage impacts.	Sediment quality is currently being investigated.	Shipping operations management measures (often supported by international agreements or legislation) are in place for ballast water, bilge water, sewage wastes, fuel/oil spillages, solid wastes, boat maintenance (including use of anti-fouling agents), and cargo spills. At Cape Lambert management measures are in place to ensure potential contaminants are collected and disposed of appropriatly.	Being done	Increased shipping operations, if not well managed, could increase the potential for contaminants to reach the environment.	Current management practices will be continued.
SOCIAL SURROUNDINGS							
Heritage *Aboriginal culture and heritage* *Non-indigenous heritage*	Ensure that the proposal complies with the requirements of the *Aboriginal Heritage Act 1972*; and Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area. Comply with statutory requirements in relation to areas of cultural or historical significance.	Identify Aboriginal cultural and heritage sites of significance through archaeological and ethnographic surveys of the project area and through consultation with local Aboriginal groups and the Aboriginal Affairs Department. Baseline studies to identify any non-indigenous heritage sites. Identify potential impacts on any identified sites. Proposed measures to manage impacts.	There are no areas of Aboriginal or heritage significance in the path of the railway or minesite.	N/A	Summaries of previous work, re-consultation with informants and government databases (O'Connor, 1997: Quartermaine, 1997). Contact with local government authorities.	None	Robe will continue to consult with Aboriginal communities and elders, and will comply with the *Aboriginal Heritage Act. 1972*
Public health and safety *Risk and hazard*	Ensure that risk is managed to meet the EPA's criteria for individual fatality risk off-site and the DME's requirements in respect of public safety.	Identification of the hazards and an assessment of the risks associated with the project, in particular, those associated with the operation of the natural gas pipeline. Proposed methods to reduce both hazards and risk.	N/A	N/A	N/A	Gas pipeline to mine power station creates a hazard.	Pipeline to be located away from residential areas and comply with Australian Standards and *WA Petroleum Pipelines Act, 1969.*

Factor and *Site specific factor* (if any)	EPA objective	Work required for the environmental review	Existing status	Existing Management	Baseline studies	Potential impacts	Proposed Management/ Predicted outcome
OTHER							
Conservation Reserves (Millstream-Chichester National Park and Karijini National Park) *Ecological function, public use and amenity*	Ensure that the functions of Conservation Reserves are not compromised.	Baseline studies of each rail route option covering the following topics: • vegetation/flora; • fauna and habitats; • landscape; • visual amenity; • noise; • watercourses/ drainage patterns; and • public use. Assessment of the potential impacts of each route on the functions of the National Park having regard to the topics identified above. Comparison/ranking of the impacts for each alternative option. Proposed measures to manage impacts.	Hamersley Iron's railway passes through Millstream Chichester National Park and through Karijini National Park in a corridor excised from the park. Part of Robe's railway to Pannawonica passes through Millstream Chichester National Park.	Existing management has been described in appropriate sections above.	See above. Summarised in Section 2.3 of this report.	Impacts depend on rail route chosen and design, construction and operation of the railroad.	Rail route chosen is close to Hamersley Iron's Railway in Millstream Chichester National Park and goes through the corridor through Karijini National Park. Refer to each environmental factor listed under "work required for public review" for management proposed. The rail route chosen minimises adverse environmental impacts.

CONTENTS

TABLES

FIGURES

APPENDICES

PART ONE

THE WEST ANGELAS PROJECT

1.0 INTRODUCTION

1.1 BACKGROUND

During the period 1972 - 1977, an extensive drilling program in the West Angelas area of Western Australia's eastern Pilbara confirmed a number of high grade iron ore deposits with a combined mineral resource of approximately 1014 Mt. The two main deposits, termed 'A' and 'B', were found to be the key areas of mineralisation, having a measured iron resource of 458 and 236 Mt respectively.

Robe River Mining Co. Pty. Ltd. (Robe) is proposing to mine Deposits A and B at West Angelas, and any economic ore proven from Deposits C - H. Transport of ore requires the construction of a rail link between the proposed West Angelas mine and Cape Lambert, and an associated increase in the capacity of the port facilities at Cape Lambert to enable the shipping of West Angelas ore. The project is being designed to have a mining and production capacity of 20 Mtpa, with a construction phase of about 30 months and an expected project life of 27 - 30 years.

At present, Robe operates an iron ore crushing, screening, stockpiling, blending and ship loading facility at Cape Lambert, with iron ore presently being transported to this facility by rail from the Pannawonica Mesa J operation.

The West Angelas proposal was referred to the Environmental Protection Authority (EPA), which determined that the level of environmental assessment be set at Environmental Review and Management Program (ERMP) under Part IV of the Environmental Protection Act, 1986.

This ERMP aims to identify the environmental impacts which may arise from the proposal and to recommend methods of reducing their effect on the environment, and has been prepared in accordance with the guidelines issued by the EPA for the project. The guidelines are included as Appendix A.

1.2 THE PROPONENT

The proponent for the proposed West Angelas project is:

Robe River Mining Co. Pty. Ltd. (ACN: 007 066 766)
9th Floor, 12 - 14 St George's Terrace
PERTH WA 6000

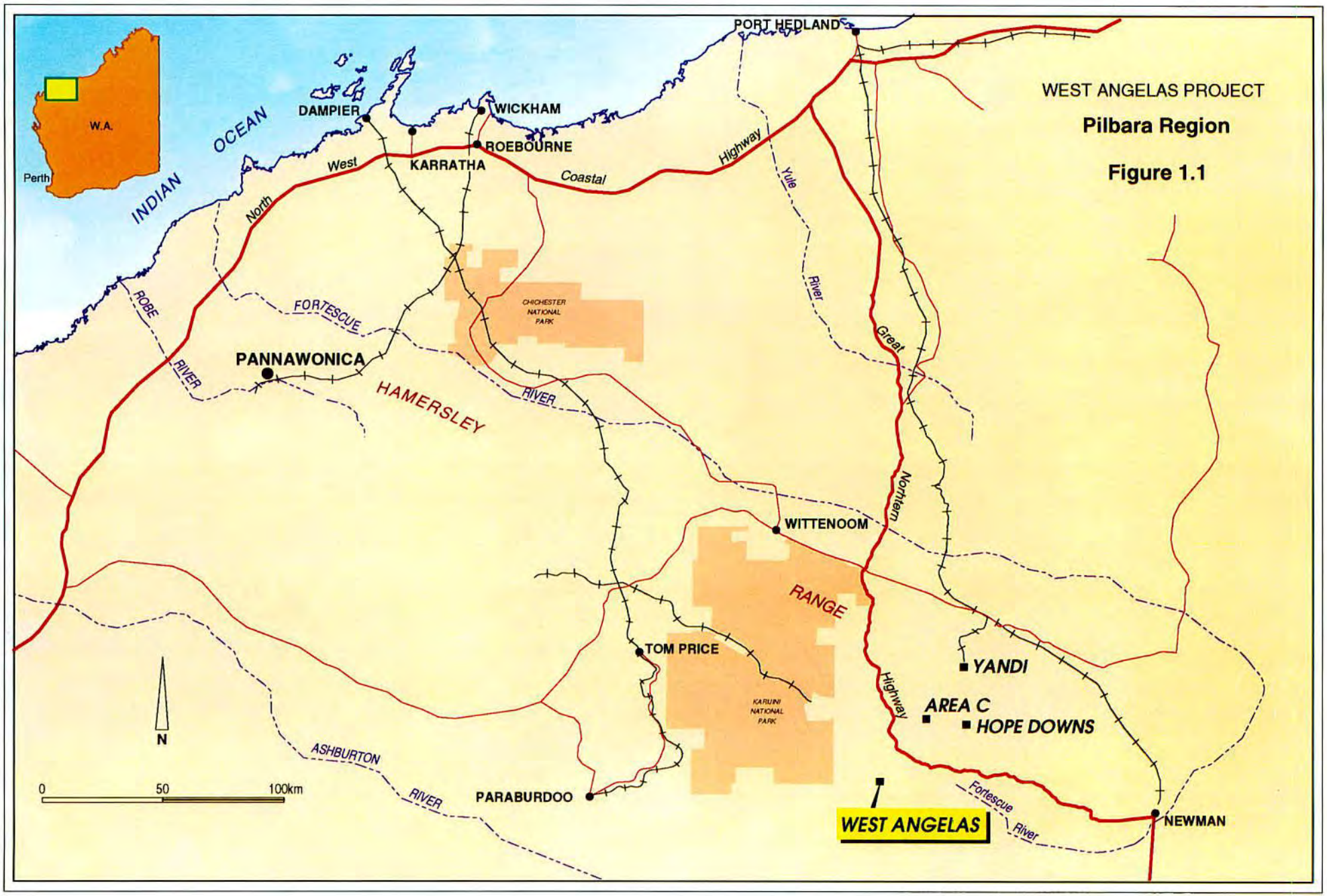
Robe River Mining Co. Pty. Ltd. are the managers of Robe River Iron Associates, which is a joint venture of:

- Robe River Mining Co. Pty. Ltd. (30 percent);
- Mitsui Iron Ore Development Pty. Ltd. (20 percent);
- North Mining Ltd. (35 percent);
- Cape Lambert Iron Associates (5 percent); and
- Pannawonica Iron Associates (10 percent).

Robe holds a number of active mining and exploration leases in the Pilbara region of Western Australia, including at Pannawonica, West Angelas and Angelo River. Robes' operations are subject to the Iron Ore (Robe River) Agreement Act 1964 - 1987.

1.3 LOCATION

West Angelas is located approximately 130 km west of Newman in the eastern Pilbara of Western Australia. Access to West Angelas is via the Great Northern Highway, turning off approximately 100 km west of Newman, and thence another 35 km along a graded, unsealed road. Port facilities are located at Cape Lambert, which is situated approximately 50 km east of Dampier and 10 km north of Wickham (Figure 1.1).


WEST ANGELAS PROJECT
Pilbara Region
Figure 1.1
W.A.
Perth
INDIAN OCEAN
PORT HEDLAND
DAMPIER
WICKHAM
ROEBOURNE
KARRATHA
West Coastal Highway
North West Coastal Highway
Yule River
Great Northern Highway
CHICHESTER NATIONAL PARK
ROBE RIVER
FORTESCUE RIVER
PANNAWONICA
HAMERSLEY RANGE
WITTENOOM
TOM PRICE
KARIJINI NATIONAL PARK
YANDI
AREA C
HOPE DOWNS
ASHBURTON RIVER
PARABURDOO
WEST ANGELAS
Fortescue River
NEWMAN
N
0
50
100km

The West Angelas Iron Ore Project proposal occurs within the Pilbara Region, which is comprised of the Shires of East Pilbara, Ashburton and Roebourne. The minesite is located within the Shire of East Pilbara, while the railway crosses through the three shire areas. Cape Lambert is located within the Shire of Roebourne.

Robe's Pannawonica and West Angelas deposits occur on ML248SA, which covers a total area of 775.8 km^2 in the Pilbara. The West Angelas deposits occur within Sections 67 - 95 of ML248SA (Figure 1.2). Sections 68 - 74 & 76 include Deposits A and B and the associated infrastructure for development. These sections cover an area of 85.14 km^2. Deposits C - H occur on Sections 67, 71, 74, 75, 77 - 80 and 82 of ML248SA.

1.4 SCOPE AND TIMING OF PROJECT

Robe are proposing the construction of a new iron ore project initially based upon the West Angelas deposits within ML248SA. The mined ore will be crushed at West Angelas before being loaded into trains and hauled to Cape Lambert for shipping. The project has the following three main components:

(i) mining - development of a large scale, 20 Mtpa open cut iron ore mine based on Deposits A and B initially, and the construction of associated infrastructure. The mine will also potentially incorporate Deposits C - H and limited mining below the water table at Deposits A and B;

(ii) rail infrastructure - construction of a rail link between the West Angelas mining areas and Cape Lambert; and

(iii) Cape Lambert facilities upgrade - to include a new train unloader, screening plant, new ship loading and port facilities.

The term 'West Angelas project' will be used in this ERMP document when considering these three components as a whole.

Robe is proposing to commence mining at Deposit A (ML248SA Sections 71, 72 & 77), and then at Deposit B (Sections 68 - 70) in Year 6 - 15 of the project life (with Year 1 commencing following the receipt of necessary approvals).

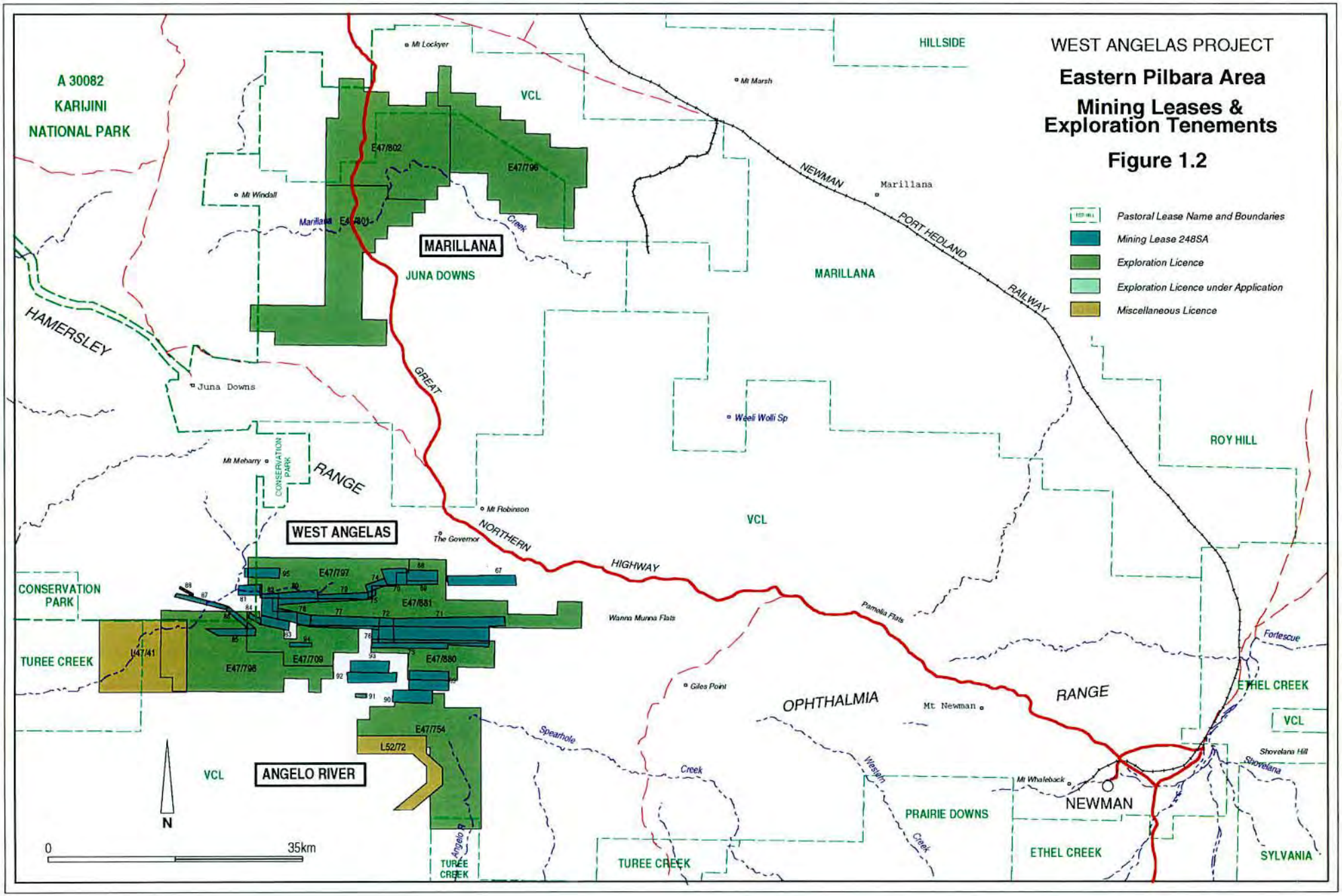
The mining of Deposits C - H at West Angelas is a possibility in the future, with an estimated 320 Mt of measured resource within these deposits (Robe River Iron Associates, 1996).

1.5 LEGISLATION RELEVANT TO PROJECT

Robe acknowledges the requirement to comply with Commonwealth and State legislation that will apply to development and operation of the West Angelas project. This legislation includes, though is not limited to, the following:

Commonwealth Government legislation

- *Endangered Species Act 1992*
- *Native Title Act 1993*


WEST ANGELAS PROJECT
Eastern Pilbara Area
Mining Leases & Exploration Tenements
Figure 1.2
Pastoral Lease Name and Boundaries
Mining Lease 248SA
Exploration Licence
Exploration Licence under Application
Miscellaneous Licence
A 30082
KARIJINI
NATIONAL PARK
HILLSIDE
VCL
MARILLANA
JUNA DOWNS
HAMERSLEY
RANGE
CONSERVATION PARK
WEST ANGELAS
CONSERVATION PARK
TUREE CREEK
ANGELO RIVER
ROY HILL
OPHTHALMIA
RANGE
PRAIRIE DOWNS
NEWMAN
ETHEL CREEK
SYLVANIA
TUREE CREEK
NEWMAN
PORT HEDLAND
RAILWAY
GREAT
NORTHERN
HIGHWAY
Creek
Spearhole
Creek
Weslafn
Creek
Angelo R
Pamelia Flats
Wanna Munna Flats
Fortescue
Shovelana
Shovelana Hill
Mt Lockyer
Mt Marsh
Mt Windall
Marillana
Juna Downs
Weeli Wolli Sp
Mt Meharry
Mt Robinson
The Governor
Giles Point
Mt Newman
Mt Whaleback
E47/802
E47/796
E47/801
E47/797
E47/881
E47/709
E47/880
E47/754
L47/41
L52/72
N
0
35km

State Government legislation

- *Aboriginal Heritage Act 1972*
- *Agricultural and Related Resources Protection Act 1976*
- *Bush Fires Act 1954*
- *Conservation and Land Management Act 1984*
- *Environmental Protection Act 1986*
- *Explosives and Dangerous Goods Act 1961*
- *Heritage of Western Australia Act 1990*
- *Iron Ore (Robe River) Agreement Act 1964 - 1987*
- *Land Act 1933*
- *Local Government Act 1960*
- *Mining Act 1978*
- *Mines Safety and Inspection Act 1995*
- *National Parks and Wildlife Act 1972*
- *Rights in Water and Irrigation Act 1914*
- *Soil and Land Conservation Act 1945*
- *Wildlife Conservation Act 1950*
- *Water Authority Act 1984*

1.6 ENVIRONMENTAL APPROVAL PROCESS

The EPA is required to assess all development proposals which may have a significant environmental effect. In this instance, the EPA has decided to formally assess the proposal pursuant to the provisions of Part IV of the Environmental Protection Act, 1986.

The EPA's formal environmental impact assessment process allows members of the public to obtain details of the proposal being assessed and to comment on any matters of interest or concern. It also enables Government authorities to consider the environmental and social implications of the proposal and provide comments as appropriate to the EPA. Government agencies involved in the approvals process may include the:

- Aboriginal Affairs Department (AAD)
- Department of Conservation and Land Management (CALM)
- Department of Environmental Protection
- Department of Health
- Department of Land Administration (DOLA)
- Department of Minerals and Energy (DME)
- Department of Resources Development (DRD)

- National Parks and Nature Conservation Authority (NPNCA)
- Water and Rivers Commission (WRC)
- West Australian Museum (WAM).

The EPA considers all comments received from government agencies and the public, and provides a summary of submissions to the proponent for their response.

In setting the level of formal environmental impact assessment for the proposed West Angelas Project at ERMP level, the EPA has required that this document be released for an eight week public review period. During this time any interested individual, community group or organisation, or Government agency can peruse the document and lodge a submission on the proposal with the EPA. This ERMP is a public document and is part of the statutory public environmental impact assessment process established by the Environmental Protection Act, 1986 (Figure 1.3).

Following completion of the public review period and receipt of the proponents response to the summary of submissions, the EPA will complete its assessment of the proposal and submit its report to the Minister for the Environment. The EPA's report to the Minister provides advice to the State Government about whether the proposal meets EPA's objectives for environmental protection.

The EPA's Assessment Report is released for a two week period during which the public can scrutinise the conclusions and, if considered warranted, appeal to the Minister against the recommendations made about the proposal. The Minister for the Environment will assess any appeals received and ultimately determine whether or not the proposal can proceed. If the Minister determines that the proposal can proceed, legally binding conditions dictating the environmental requirements with which the proponent has to comply will be set pursuant to Section 45 of the Environmental Protection Act, 1986.

Thus, in order for the proposed West Angelas project to proceed, the following statutory requirements need to be completed:

- release of this ERMP for an eight week public review period;
- DEP prepare a summary of submissions received from Government agencies and members of the public;
- proponent provides the DEP with written responses to all issues raised in submissions received during the public review period. Where appropriate, the proponent may amend the proposal and/or change the management commitments in response to comments raised during the public review period, provided those changes do not significantly increase environmental impacts;
- the DEP submits an evaluation of project impacts to the EPA, and any additional requirements to ensure that the proposal would satisfy environmental policies and objectives;
- the EPA provides its advice to Government on the proposal through its Assessment Report made to the Minister for the Environment. The Report and Recommendations are released to the public, and there is a 14 day appeal period regarding the Report.
- the Minister determines any appeals against the EPA's Report and if the proposal is regarded as environmentally acceptable, sets legally binding conditions on the proponent; and
- the project is commenced according to the Ministerial Conditions and Proponent Commitments set out in the Statement that a Proposal may be Implemented (Pursuant to the Provisions of the Environmental Protection Act, 1986).

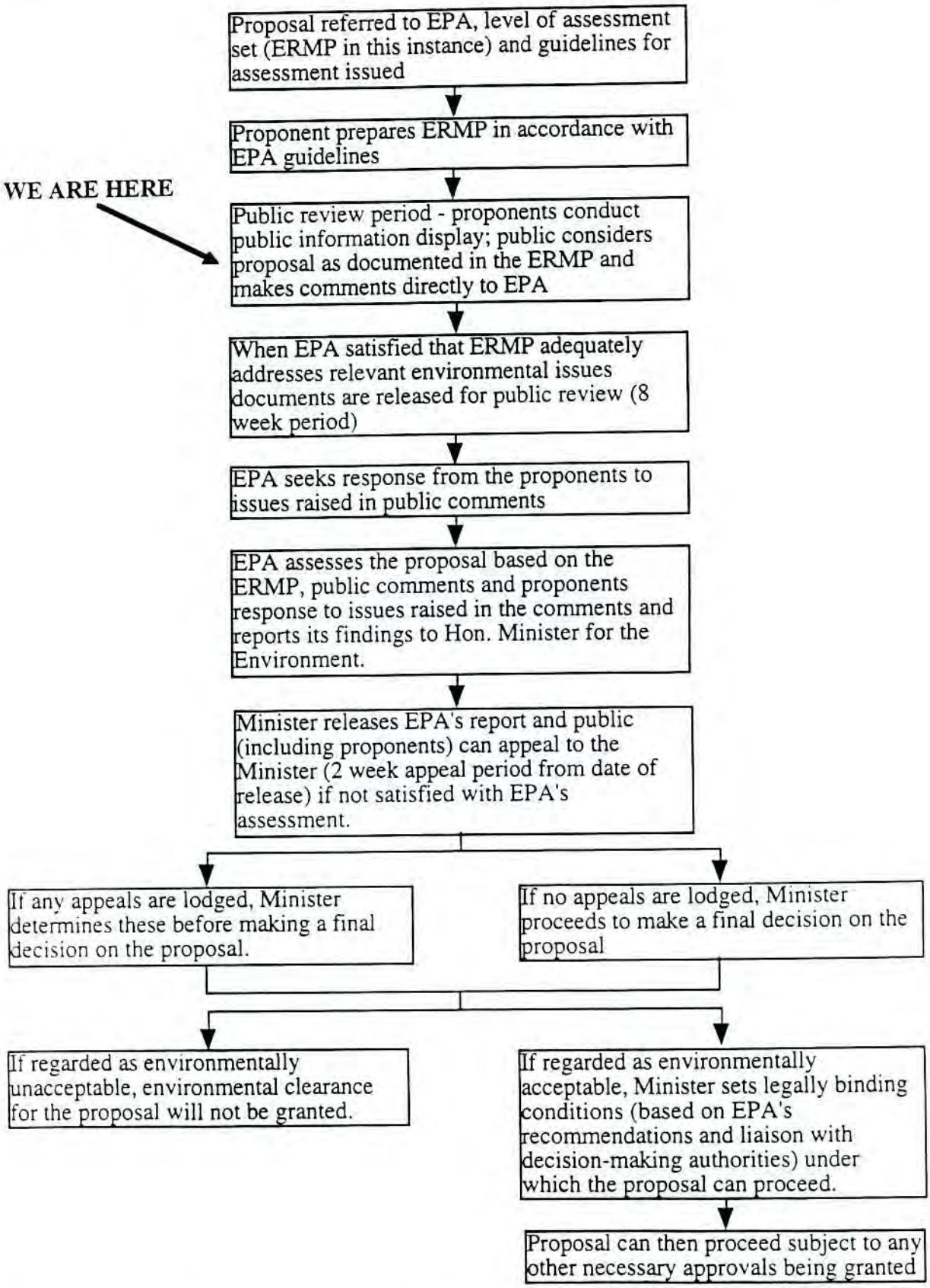


Figure 1.3: The Environmental Protection Authority's assessment process

1.7 OBJECTIVE AND STRUCTURE OF THE ERMP

The objective of the ERMP is to provide the EPA with information about the proposal as a basis for its assessment of the project, and to inform interested parties about the project so that they are in a position to contribute to the environmental impact assessment process if they so wish. The structure of the ERMP is outlined below.

CHAPTER	CONTENT
1	Provides project background and the assessment process to gain approval.
2	Provides justification for the proposal to proceed and an evaluation of alternatives.
3	Description of the project components.
4	Describes public consultation and government liaison undertaken for the proposal.
5	Describes the existing biological and human environment within the project area.
6	Describes environmental impacts associated with the biophysical environment and management strategies for these.
7	Describes potential for pollution generation and where necessary management strategies to minimise pollution.
8	Describes social environment impacts and management strategies for these.
9	Discusses other proposal aspects with multiple environmental factors.
10	Discusses Environmental Management Systems.
11	Summary of key commitments.

2.0 PROJECT JUSTIFICATION AND EVALUATION OF ALTERNATIVES

2.1 PROJECT JUSTIFICATION

Studies of the West Angelas iron ore deposits and associated requirements for project development have been undertaken since the late 1970s. Most recently, a Scoping Study was undertaken to determine the overall viability of the project (Robe, 1997a). The Scoping Study has resulted in a decision to proceed to more detailed feasibility assessment and to initiate the Governmental Approval process to allow the development to occur.

The components of the West Angelas project are completely interconnected such that no one component can be undertaken on its own. For example, the mining is dependant on both the rail link and the expansion of Cape Lambert to facilitate the shipping of the West Angelas lump and fines. The project must therefore be considered in its entirety.

2.1.1 National and State Benefits

World iron ore production totals approximately one billion tonnes per annum, with iron ore forming the principal raw material for crude steel production. Demand for iron ore is increasing from China, Taiwan and Korea with an established market in Japan. Due to the proximity of Western Australia to the high-growth Asian economies, sea borne trade is established and is forecast to increase (DRD, 1996).

In 1996, Western Australia was the world's largest exporter of iron ore, producing 134 Mt worth $3 billion. The Pilbara region generates iron ore valued at more than $2.5 billion per year (Pilbara Development Commission, 1996). Robe is Australia's third largest iron ore producer and fourth ranked iron ore exporter in the world (DRD, 1997).

The West Angeles mine would utilise ore from the Marra Mamba geological formation. Development of the Marra Mamba ore deposits represent a second generation of the iron ore industry in the Pilbara, providing a new type of ore which increases the diversity of products and increases market opportunities.

The mining of the iron ore deposits at West Angelas will result in substantial national and state benefits, including:

- investment in excess of one billion dollars capital most of which will be directed into the Western Australian economy;
- increased export value of Western Australian iron ore products to international customers;
- additional Commonwealth and State Government revenues through collection of additional royalties, taxation and other charges;
- direct employment in the eastern Pilbara, peaking at around 1 200 people during construction and over 450 during operation;
- more efficient use of existing infrastructure at Cape Lambert and the township of Wickham;
- increasing demand for goods and services creating business and employment opportunities; and
- potential for development of downstream processing.

In addition to the direct benefits of a mining proposal, there are flow-on benefits to the non-mining

sector. The multiplying factors of mining for the rest of the economy have been estimated as:

- any increase in output of mining results in a two fold increase in the output of non-mining industry
- a $1 million increase in mining wages and benefits results in a $2 million increase in the non-mining sector; and
- for every 100 jobs created in the mining industry approximately 300 non-mining jobs result.

(MacLeod & Gerhardy, 1996).

From an economic perspective, the West Angelas project will provide both direct and indirect employment opportunities in the eastern Pilbara, as well as a substantial investment in infrastructure.

Robe have an iron ore pelletising plant located at Cape Lambert which is not currently operational. The plant agglomerates iron ore particles to form pellets for use as blast furnace feed. The supply of ore from West Angelas is being assessed for the feasibility of re-opening the pellet plant, thereby promoting the use of downstream processing within the iron ore industry. Although the potential to produce pellets from West Angelas ore is being evaluated, recommissioning of the pellet plant is not included in the scope of this ERMP.

2.1.2 Need for the Proposal

The Pilbara Region's economy is based upon mineral resource projects and its future growth and development are dependant on the continued viability of the resource development projects. Iron ore exploration, exploitation and export are essential components of the Pilbara Region and the State's employment and economic outlook.

Development of Marra Mamba ore types will be crucial for the iron ore industry in Western Australia, as the premium quality low phosphorous ore deposits of the Brockman Formation are gradually depleted. The output of Marra Mamba ore is likely to increase as the ore moves from being initially a small part of the blend, to potentially becoming a major base component of iron ore products (DRD, 1997).

Iron ore is a derived demand due to its status as a raw material in the steel production process. Growth in steel production is forecast to be via the Electric Arc Furnace (EAF) process which alters the quality and form of iron ore products required, in comparison to those used for steel production through blast furnaces. The EAF process utilises scrap steel, direct reduced iron (DRI) and hot briquetted iron (HBI) which require higher grade iron ore than the lump ore required for the blast furnace process.

The diversion of high grade iron ore products to EAF steel producers will create an increased demand for blast furnace feed. High grade iron ore is likely to be utilised in the production of DRI for the EAF process which will result in a diminished supply to the blast furnace feed market. West Angelas iron ore will be suitable to provide a consistent alternative supply to the predominantly South East Asian and China markets.

The West Angelas project will also provide a diversified product for Robe, which currently produces mainly single pisolitic sinter fines. West Angelas ore contains higher grade fines with a proportion of lump ore to provide variety in the blends and products available.

2.2 EVALUATION OF ALTERNATIVES

2.2.1 Mining

At present, there are no viable alternative mining areas within Robe's mining leases. The Angelo River area, south of West Angelas, consists of an Exploration Licences (E47/754) which covers an outcropping Marra Mamba Iron Formation.

Exploration work is continuing in this project area, and in others south-west of Pannawonica, but as yet, no other economically viable alternative mining areas to West Angelas have been identified.

2.2.2 Railway

Rail provides the most appropriate means of transport of the large quantities of ore produced at West Angelas to Cape Lambert. Transport of the ore by road or air are not economically viable and will not be considered.

The issue is therefore the location and planning of the rail route between the West Angelas minesite and Cape Lambert. Several alternative routes have been considered and these routes and the selection process applied to choosing the preferred rail route is given in Section 2.3.

2.2.3 Port Facilities

The Cape Lambert port facility is owned and operated by Robe for export of iron ore from the Pannawonica operations. There is no viable alternative to the use of Cape Lambert as a port for shipping the West Angelas iron ore.

Due to the increased volume of ore for export, expansion of the Port is required in terms of stockpile areas, transport and loading equipment, and the number of berths available. These alterations are required in order to allow simultaneous loading of Mesa J and West Angelas ore into berthed ships and to ensure that Robe will be able to load the anticipated increase in shipping.

Wharf Extension

Simulation work was performed on existing and future port operations with the expected increases in ore exports from Mesa J and additional volumes of ore from West Angelas production (Robe, 1997a). Options considered for expansion of the Port facilities were:

(i) one shiploader two berths;

(ii) two shiploaders two berths; and

(iii) two shiploaders and extended berthing facilities to accomodate three or four vessels.

The first scenario comprises that of the existing facilities with an increase in exports. This situation could accommodate increases in Mesa J exports, but would lead to excessive demurrage costs with the addition of West Angelas product. The addition of another shiploader servicing the existing two berths would allow for a significant increase in ore loading capacity. However, shipping efficiencies would still be limited due to loader to loader interference and associated ship handling delays.

The third option of an additional shiploader and extension to the existing berths found that a wharf extension allows the shiploaders to operate with minimal interference and increased port throughput. This option accommodates the increased volume of ore from West Angelas coming on-line and allows for increased exports by increasing the number of ships that can berth at the facility. This

option is therefore considered optimum for efficient and cost-effective ore transport and is the scenario adopted for the purposes of the assessment process.

Ore stockpile Extension

The increased ship loading capacity requires a corresponding ore stockpile capacity. The proposed stockpile expansion entails the enlargement of the existing stockpile by an additional 44.4 ha. The enlargement requires the reclamation of land.

There are no viable alternatives to the land reclamation due to the constraints imposed by the topography, lease boundary and location of sensitive habitats within Robe's lease area at Cape Lambert.

2.2.4 Water Supply Options

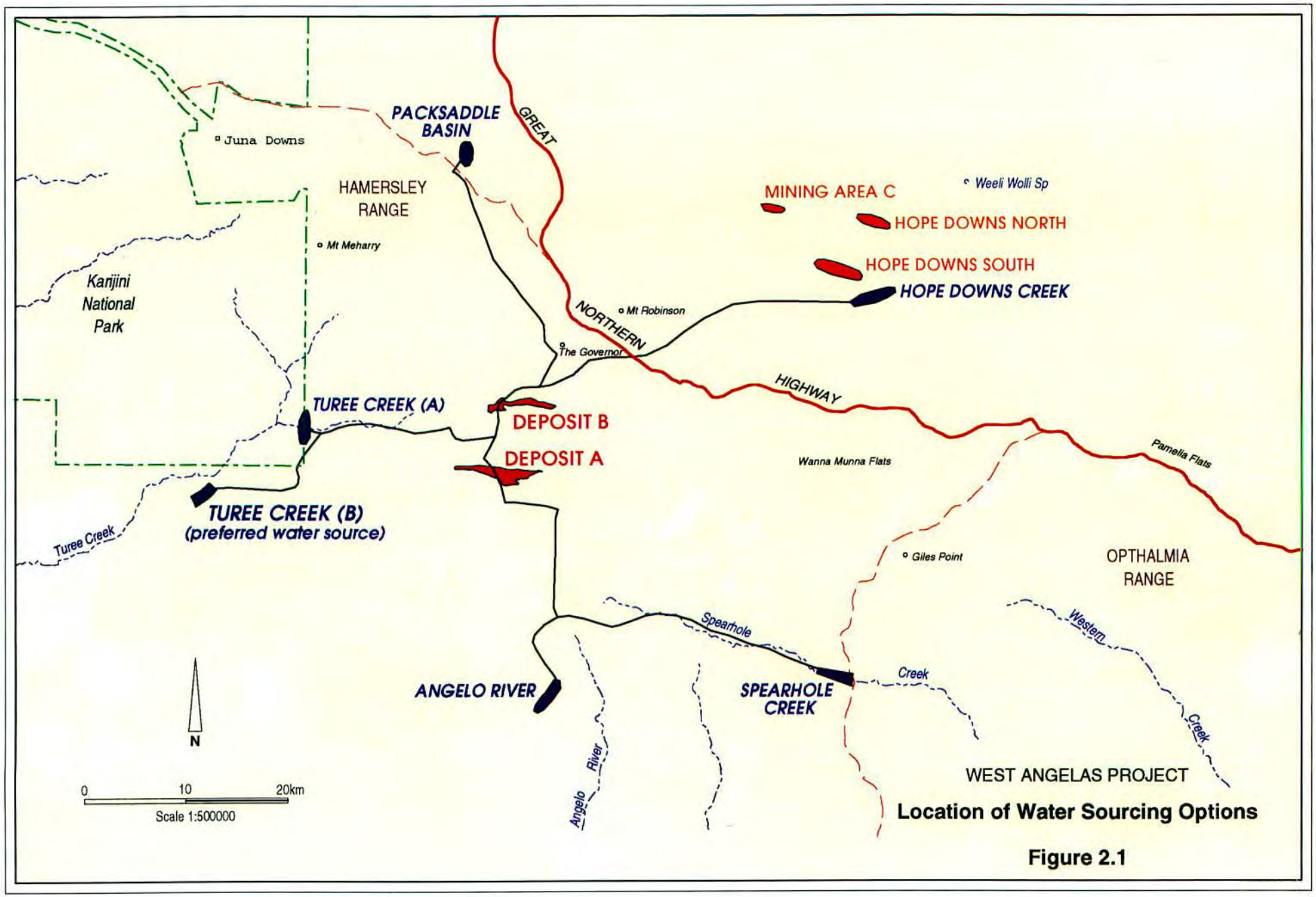
Preliminary investigations indicated that there was little groundwater potential close to the West Angelas deposit and alternative supplies within a 70 km radius were investigated (Figure 2.1). Existing data for the area show that the Tertiary-Quaternary valley fill deposits and the Proterozoic Wittenoom formation are the only regionally significant potential aquifers.

Six potential locations were considered and ranked on the basis of potential groundwater yield, cost of development, environmental and logistical constraints. The results are summarised in Table 2.1.

Based on the results of the initial ranking process, exploratory drilling and groundwater resource development potential is focused on the Turee Creek (B) option.

Table 2.1: **Summary of water supply options for the West Angelas Iron Ore Project proposal.**

Rank	Location and Distance from West Angelas	Catchment Area (km^2)	Potential Yield (Mgl/d)	Constraints
1	Turee Creek (B) 31.25 km west	650	11	-
2	Packsaddle Basin 27.5 km north	440	8	On BHP leases
3	Angelo River 27.5 km directly south	250	4	Small catchment
4	Turee Creek (A) 20 km due west	350	6	East of and adjacent to Karijini NP
5	Hope Downs Creek 37.5 km to the north-east	350	6	Cost
6	Spearhole Creek 37.5 km to the south-east	220	4	Cost Small catchment


PACKSADDLE BASIN
GREAT
Juna Downs
HAMERSLEY RANGE
Mt Meharry
Karijini National Park
MINING AREA C
Weeli Wolli Sp
HOPE DOWNS NORTH
HOPE DOWNS SOUTH
HOPE DOWNS CREEK
Mt Robinson
NORTHERN
The Governor
HIGHWAY
TUREE CREEK (A)
DEPOSIT B
DEPOSIT A
Wanna Munna Flats
Pamelia Flats
TUREE CREEK (B)
(preferred water source)
Turee Creek
Giles Point
OPTHALMIA RANGE
Spearhole
Western
Creek
ANGELO RIVER
SPEARHOLE CREEK
Creek
Angelo River
N
0
10
20km
Scale 1:500000
WEST ANGELAS PROJECT
Location of Water Sourcing Options
Figure 2.1

Water requirements for the West Angelas project are estimated to be between six and 16 ML per day. Investigations have determined that the Turee Creek (B) borefield site which is located downstream of Karijini National Park is expected to be able to supply around 8-9 ML/d, and further investigations are taking place to the west of Turee Creek (B).

2.2.5 Worker Accommodation

The Scoping Study for the West Angelas project determined that worker accommodation would be in a purpose built on-site village as Newman is too far away for regular daily commuting (See Figure 1.1). Four sites have been considered for the accommodation village and evaluated on the basis of topography and aesthetics, micro-climate, environmental disturbances, accessibility, and infrastructure (Robe, 1997b). The sites are:

(i) Northern Site - located 9 km from minesite on the southern and south-eastern slopes of the West Angelas hills. This is the location of the current exploration camp;

(ii) Southern Site - located 9.5 km from the minesite on the southern slopes of the West Angelas valley;

(iii) Western Site - located 12 km from the minesite at the western end of the West Angelas hills; and

(iv) Eastern Site - 21 km from minesite on the southern side of Mt Hilditch and Mt Ella.

Aesthetics and topography

All sites were found to be adequate to support the village and construction camps, with good elevation and views. The Eastern site is the only one that will not overlook mining operations eventually. The order of preference for this factor was Eastern, Western, Southern and Northern sites.

Micro-climate

The Western and Eastern sites have best shelter from prevailing easterly winds followed by Northern and Southern sites.

Environmental Disturbance

This factor relates mostly to noise and dust disturbance from the mining operation and railway. The Eastern site is the only one which will not be affected. The Northern site is likely to be adversely affected by noise and dust, with some impact being experienced at the Southern site and least impact at the Western site.

Accessibility

The Western site would involve an additional 3 minutes of travel time over the Northern and Southern sites. The Eastern site involves considerably longer travel time than the other sites.

Infrastructure

This relates to drainage, services, soils and landscaping, and provision of services, roads, power and water. These factors are relatively even between the four sites, although the fact that the Southern site has been subject to sheet flooding is significant. The Western site has more than adequate soil depth over rock.

In comparing the four sites, the social issues had a 2:1 ranking over cost issues. Based on social issues, the order of site preference is Western, Eastern, Northern and Southern sites respectively. With financial costs added, the Northern site becomes preferable followed closely by the Western site. However, due to railway noise and dust issues the Northern site has not been recommended as the preferred village location. The Western site is nominated as the preferred location as it is considered to best reflect a compromise between social, environmental and cost issues.

2.3 ORE TRANSPORT

Alternatives considered for ore transport included sharing rail infrastructure with Hamersley Iron and a range of different route options between the West Angelas Minesite and Robe's stockpiling and ship loading facility at Cape Lambert. These are detailed below.

2.3.1 Shared use alternatives

Double tracking and use of Hamersley Iron's main Dampier to Tom Price railway line was one of the options considered. This would involve constructing a single track to Marandoo, utilising Hamersley's single track railway through Karijini National Park to Rosella Siding (the Marrandoo Junction), then double tracking over the main Dampier to Tom Price section by connecting the ends of Hamersley Iron's existing passing sidings between Rosella siding and the Robe Overpass. This option would include improving sections of the track, particularly the existing bad curves through the Millstream-Chichester National Park and other areas of the track that damage ore car draw gear.

This proposal was forwarded to Hamersley Iron for their consideration of an independent Central Pilbara rail operator.

The Central Pilbara rail option has its advantages and disadvantages for Robe River, these being:

Advantages

- the length of the new track required for accessing West Angelas would be reduced to approximately 250 km with a reduction in capital costs for construction of the line.
- the need for trains to stop at passing sidings would be eliminated on dual track sections which reduces round trip cycle times around two (2) hours per trip, which represents saving of approximately eight percent (8percent) of total train cycle time. This reduction in running time enables more time for dumping of loaded cars hence the need for purchase of additional cars for making-up time is eliminated.
- the reduced time for empty and loaded trains results in fuel cost savings.
- Robe's track maintenance costs are reduced as a result of sharing this cost with Hamersley Iron.
- operation of the lines would be considerably simplified for both parties and the potential for head collisions and accidents at passing sidings eliminated over the full length of the parallel tracking.
- dual track reduces the risk of train schedule delays and derailments.

Disadvantages

- All train movements on the parallel track would be controlled by Hamersley, whereas currently Robe has full control of all operations
- length of rail haul is increased, adding to distance travelled by locomotives and ore cars, this reducing fuel cost saving and adding roll stock maintenance cost.
- rail operating systems would need to be compatible and this would add capital cost.

The option of dual tracking the Hamersley railway line was forwarded to Hamersley Iron in February 1997, and in July 1997 a more detailed proposal followed. This was rejected by the RTZ Board and instead Hamersley advised that they may be interested if:

- Hamersley was contracted as the carrier for Robe's ore from West Angelas to Cape Lambert, and
- Hamersley would construct and pay for the necessary track, communications and all rolling stock, including locomotives and ore wagons. Under this proposed operation, Robe would be required to pay a negotiated capital service charge and an operating charge, based on operating costs and a management fee.

This Hamersley proposal was not seen as a cost effective option for the Robe participants, nor did it deliver an independent controlled railway option with balanced ownership.

For this reason, the paralleling of the Hamersley Iron railway track was rejected as an option.

This does not rule out the possibility of a dual track option in the future when the West Angelas railway line is constructed, providing an independent management structure could be agreed to.

2.3.2 Comparison of Route Options

All feasible routes require access through both Chichester Range National Park and within the transport corridor through Karijini National Park. The EPA's Guidelines recognised this and specified a "Conservation Reserves (Millstream-Chichester National Park and Karijini National Park)" environmental factor with the objective being to "ensure that the functions of the conservation reserves are not compromised".

Route options considered are shown in a summary format in Figure 2.2 and at a scale of 1:100 000 in Appendix B.

The guidelines specify that assessment of the impact of the railway alignments are to consider the following topics:

- vegetation / flora;
- fauna and habitats;
- landscape;
- visual amenity;
- noise;
- watercourse/drainage patterns; and
- public use.

However, railway route selection also needs to consider other factors, such as engineering, and economic concerns. The following section explains the basis for each alternative route option presented in the Referral Document (Figure 2.2), then assesses each of the options and the explains the reasons for adoption or rejection of a particular route. Reference is made to environmental, engineering and economic factors.

The criteria against which options were evaluated appear in Table 2.2 below.

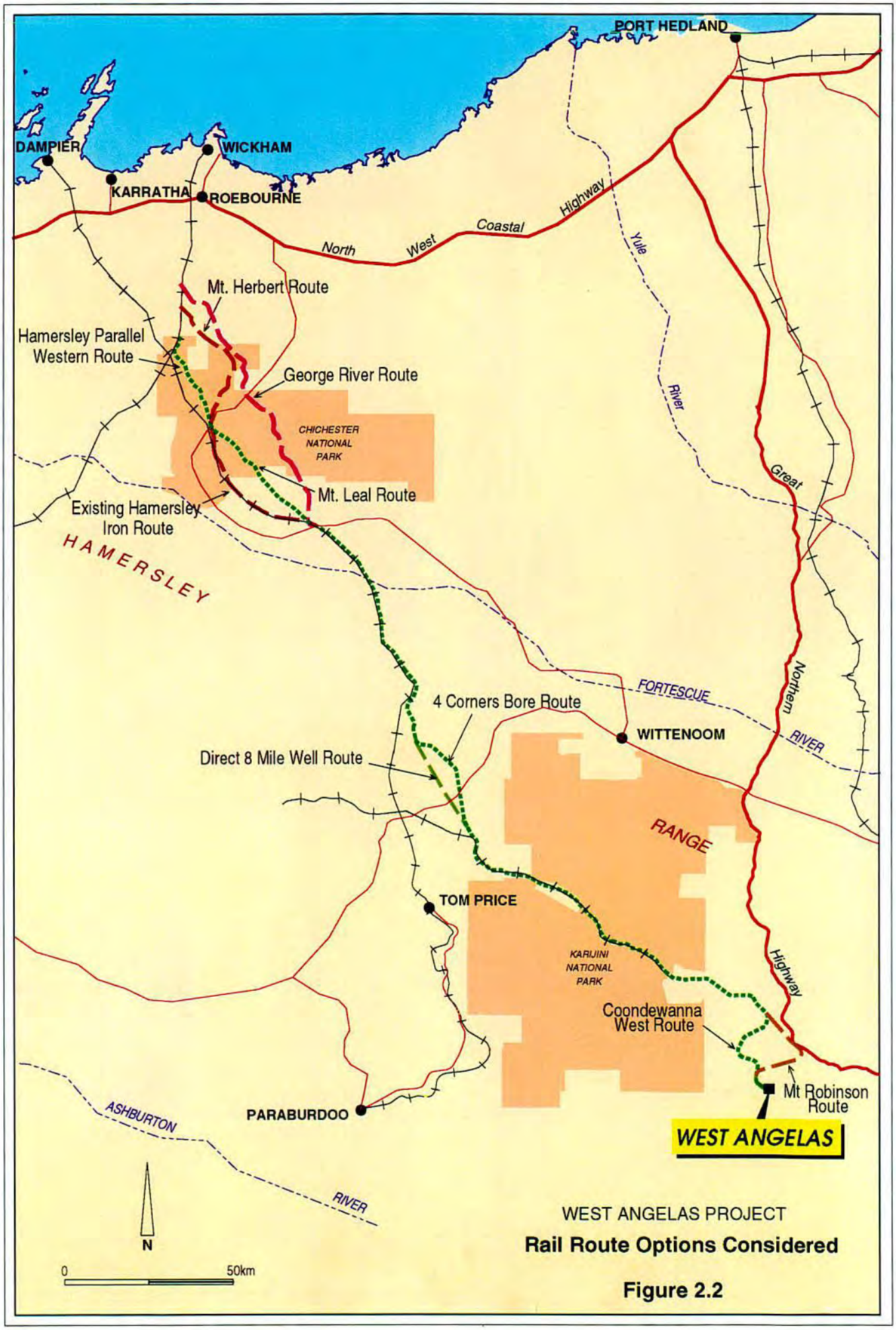

PORT HEDLAND
DAMPIER
WICKHAM
KARRATHA
ROEBOURNE
North West Coastal Highway
Yule River
Great Northern Highway
Mt. Herbert Route
Hamersley Parallel Western Route
George River Route
CHICHESTER NATIONAL PARK
Mt. Leal Route
Existing Hamersley Iron Route
HAMERSLEY RANGE
4 Corners Bore Route
Direct 8 Mile Well Route
FORTESCUE RIVER
WITTENOOM
TOM PRICE
KARIJINI NATIONAL PARK
Coondewanna West Route
Mt Robinson Route
WEST ANGELAS
PARABURDOO
ASHBURTON RIVER
N
0
50km
WEST ANGELAS PROJECT
Rail Route Options Considered
Figure 2.2

Table 2.2: Some route selection criteria for comparison of rail options.

Route Selection Criteria	Severity	Description
Capital Cost	Severe	Variance from Preferred Route >$5M
	Medium	Variance from Preferred Route >$2M<$5M
	Mild	Variance from Preferred Route >$0.5M<$2M
	Negligible	Variance from Preferred Route >$0.5M
Operating Cost per annum	Severe	Variance from Preferred Route >$0.25M
	Medium	Variance from Preferred Route >$0.15M<$0.25M
	Mild	Variance from Preferred Route >$0.05M<$0.15M
	Negligible	Variance from Preferred Route >$0.05M
Construction Restrictions	Severe	Route adjacent to existing railroad + rock cuts
	Medium	Route adjacent to existing railroad
	Mild	Route partially adjacent to existing railroad
	Negligible	Route intersects existing railroad only
Availability of Construction Materials	Severe	Majority fill material needs to be imported >2km
	Medium	Some fill material needs to be imported >2km
	Mild	Fill material readily available
	Negligible	Good balance of cut and fill
Effect on Surface Hydrology	Severe	Bisects floodwash area
	Medium	Crosses major/multiple watercourses
	Mild	Crosses minor watercourses
	Negligible	Minimal impact on drainage systems
Land Availability	Severe	Majority of route is through National Park
	Medium	Some of route is through National Park
	Mild	Route traverses other lease(s)
	Negligible	Corridor readily available
Public of use Land	Severe	Popular tourist venue
	Medium	Non-organised tourist area
	Mild	Remote tourist area
	Negligible	Non tourist area
Noise Pollution	Severe	Train passes immediately adjacent to tourist activity
	Medium	Train passes more than 5 km from tourist activity
	Mild	Train passes more than 10 km from tourist activity
	Negligible	Train remote from tourist activity
Visual amenity	Severe	Train in full view of tourist activity
	Medium	Train in partial view of tourist activity
	Mild	Train in background of tourist activity
	Negligible	Train not visible from tourist area

A noise study was undertaken of the Hamersley Parallel (Western) route to determine likely impacts on tourist locations and wilderness areas within the Millstream-Chichester National Park (ERM Mitchell McCotter, 1997). The study predicted noise levels using the Environmental Noise Model which permits noise prediction under a range of meteorological conditions and takes into account topography. The model provides noise contours which represent the train at every location along the route. Noise measurements from trains operating on the existing Hamersley Iron line were used as input into the model.

The worst case scenario which occurs during a strong temperature inversion found noise levels at Python Pool would be about 30 dB (A), but in most conditions ranged between less than 30 to approximately 20 dB (A). Discussions with the Bureau of Meteorology indicated that such strong temperature inversions will generally be present for only a few hours before being dispersed by wind or variations in ambient air temperature.

The least noise impact occurred during south-easterly breezes, which is the most predominant wind direction. With a south-easterly breeze and no inversion, modelled noise levels were 20 dB (A).

As there is no legislation governing allowable noise levels in wilderness areas in Western Australia, the impacts need to be assessed against existing background levels.

Background noise levels at Python Pool in September 1997 were 22 dB (A) when there was a very light breeze and no pedestrian of vehicular activity in the area. Although train noise would be able to be noticed under worst case conditions, since a 5 dB (A) change in noise levels is clearly noticeable, any human activity would easily override the train noise.

It is considered that there would be few occasions when train noise would be noticeable at Python Pool if the Hamersley Parallel (Western) route is used (ERM Mitchell McCotter, 1997).

Northern Chichester Range rail options

Three main routes, the George River route, Mt Herbert route and Hamersley Parallel (Western) route were identified in referral documentation to the Environmental Protection Authority. The George River route has since been discounted as an option, and the Mt Herbert and Hamersley Parallel (Western) routes further investigated. The reasons for discounting the George River route are given below, and this is followed by a comparison of the Mt Herbert and Hamersley Parallel (Western) routes.

(i) George River route

When initial studies were carried out in the 1980's for a railroad which linked Cape Lambert to the West Angelas Mine, the most direct railroad route was selected between key points to incur the least cost. This included the George River route.

The George River route would have involved the construction of a new route heading north-north-west, passing approximately 750 m east of Mt Montagu, crossing the George River and Narrina, Carolina and Springs Creeks, meeting up with the Pannawonica - Cape Lambert Railway approximately 10 km north of the Millstream - Chichester National Park (Figure 2.2).

Examination of the George River route has found that:

- the country is very rugged, with high landscape values and as a result this rail formation would be expensive to construct;
- CALM indicated that the central and eastern portions of Millstream Chichester National Park would be zoned as a wilderness area. This route would therefore result in significant noise impacts and provide access tracks which could unacceptably increase public use of the area;
- this route does not meet CALM's request that all services remain within an acknowledged service corridor through the Millstream Chichester National Park; and

- Hicks Gap has significant non-indigenous heritage value.

Due to the high degree of environmental sensitivity, Robe deleted this route from further consideration.

(ii) Mount Herbert route compared with Hamersley Parallel (Western) route

The Mount Herbert Route branches to the northeast away from the Hamersley Iron Railway just north of Barowanna Hill, heads generally north for approximately 23 km, and then heads north-west for 15 km to meet up and merge with the existing Robe River Railway (Figure 2.2). Two routes along the Mt Herbert alignment were investigated using the criteria detailed in Table 2.2 (above). Both routes presented acceptable gradients through the Chichester Range and skirt the area of collapsing soils.

Routes parallel to Hamersley's railway were investigated in order to meet CALM's request that Robe's Railway be contained within a service corridor adjacent to Hamersley Iron's Railway. Eight alignments were closely studied within five kilometres of the Hamersley railroad. Most of the eight routes which were relatively shorter than the Mt George and Mt Herbert options presented significant topographic or surface drainage constraints in addition to the difficulty in achieving a suitable gradient in ascending the Chichester Range, construction would result in significant earthworks and landscape impacts. Three of the Hamersley Parallel routes were investigated using the criteria detailed in Table 2.2 (above). Table 2.3 presents an analysis of the two options using the criteria in Table 2.2.

Table 2.3: Mt Herbert options compared with Hamersley parallel options

	Mt Herbert		Hamersley Parallel		
					Western
Route	HE7	HE8	HP8	HP9	HP10
Length (Km)	41.73	41.48	31.40	34.20	31.90
Maximum Grade - Empty	1.53	1.61	1.82	1.68	1.91
Maximum Grade - Loaded	0.15	0.15	0.31	0.33	0.26
Capital Cost Variance	Severe	Severe	Negligible	Medium	Preferred
Operating Cost pa. Variance	Mild	Mild	Negligible	Mild	Preferred
Construction Restrictions	Negligible	Negligible	Mild	Negligible	Negligible
Availability of Construction. Materials.	Medium	Medium	Medium	Medium	Medium
Effect on Surface Hydrology	Severe	Severe	Medium	Medium	Medium
Land Availability	Severe	Severe	Severe	Severe	Severe
Public of use Land	Severe	Severe	Medium	Medium	Medium
Noise Pollution	Severe	Severe	Medium	Medium	Medium
Visual amenity	Severe	Severe	Medium	Medium	Medium

Information contained in Trudgen and Casson (1998) would enable evaluation of impacts in relation to vegetation. However, given that the westerly route examined near the Hamersley railroad is of shorter length resulting in considerable savings both in operating and capital costs, achieves acceptable gradients, and is preferred by the Department of Conservation and Land Management because it is further from the proposed Wilderness area in Millstream Chichester National Park. The western route was selected without further analysis of other factors such as vegetation or flora.

Lower section of the Millstream - Chichester area

Mt Leal Route compared with the existing Hamersley Iron Route

The Mt Leal Route branches to the north away from the Hamersley Iron existing rail line just north of Cowcumba Creek. This route option continues in a north-west direction to just south of Mt Leal, and finishes at a point approximately 2 km north of Barowanna Hill. The Hamersley Iron Parallel Route parallels the Hamersley Iron Railway from Cowcumba Creek north to a point 2.5 km north of Barowanna Hill.

The existing Hamersley Iron rail alignment intersects a low lying flood wash area where run-off from the immediate hilly areas is only just commencing to form into defined drainage paths. By locating the railway further east, a major portion of the floodplain can be avoided, together with the associated drainage problems. Being on higher ground also avoids the likely occurrence of collapsing soils which tend to be more common in flood wash areas. Locating the railway further east also reduces the length of railway to be constructed by 6.5 km.

Table 2.4 compares the Mt Leal with the existing Hamersley Iron route using the criteria in Table 2.2 and the information noted in the paragraph above.

Table 2.4: Mt Leal option compared with existing Hamersley Iron alignment options

Route	Mt. Leal	Existing H.I.	Comments
Length (Km)	41.0	45.3	
Maximum Grade - Empty	0.72	0.87	
Maximum Grade - Loaded	0.18	0.33	
Capital Cost Variance	Preferred	Medium	
Operating Cost pa. Variance	Preferred	Mild	
Construction Restrictions	Negligible	Medium	
Availability of Construction. Materials.	Medium	Severe	Collapsing Soils in Flood plain on H.I. existing route
Effect on Surface Hydrology	Medium	Severe	
Land Availability	Medium	Medium	
Public use of Land	Medium	Medium	
Noise Pollution	Mild	Mild	
Visual amenity	Medium	Medium	

No biological survey work was undertaken along the Existing Hamersley Iron alignment, so comparisons can not be made. The Mt Leal Route is the selected option based on lower capital and operating costs and concerns that the Hamersley Iron route has materials and hydrology problems resulting from crossing flood plains.

Hamersley Station Plain Rail Options

Four Corners Bore Route compared with the Direct Eight Mile Route

An alternative alignment to Hamersley's alignment needs to be chosen for this section of railway to avoid having to widen the long cutting about eight kilometres south of Mt Lois which would interfere with Hamersley's operations. Furthermore, Hamersley's alignment is significantly longer. Two alternatives were investigated to the Hamersley alignment, namely the Four Corners Bore route and the Direct Eight Mile route.

The Four Corners Bore Route option heads away to the north from the Hamersley Iron Central Pilbara Railway from approximately 4.5 km north of Gorton Mill Bore, which is located immediately adjacent to the Central Pilbara Railway. This route passes to the north of Four Corners Bore, before deviating north-west to meet up with the Hamersley Iron Railway approximately 7 km east of Satellite Spring.

The Direct Eight Mile Well Route option is the most direct of the two options in the Hamersley Range. However, the route traverses low lying terrain with cracking clays. The route comprises an almost straight line between Gorion Hill Bore and a point approximately 7 km east of Satellite Spring, passing just to the north of Eight Mile Well Bore. The route passes over fertile grazing land which is part of Hamersley Station and would present a physical barrier to stock. This route would also be located on collapsing clay soil which requires embankment foundation stabilisation.

Although the Four Corners Bore Route is 1.5 km longer than the Direct Eight Mile Well Route, construction costs would be similar with the benefit of less adverse influence on the operations of Hamersley Station. Table 2.5 compares the Four Corners Bore route with the Direct Eight Mile Well route using the criteria in Table 2.2 and the information noted in the paragraphs above.

Table 2.5: **Four Corners Bore option compared with Direct Eight Mile Well alignment options**

Route	Direct Eight Mile Well	Four Corners Bore	Comments
Length (Km)	23.5	25.0	
Maximum Grade - Empty	n/a	0.60	
Maximum Grade - Loaded	n/a	0.33	
Capital Cost Variance	(Mild)	Preferred	
Operating Cost pa. Variance	Negligible	Preferred	
Construction Restrictions	Negligible	Negligible	
Availability of Construction. Materials.	Severe	Mild	Collapsing soils on Direct route
Effect on Surface Hydrology	Severe	Medium	
Land Availability	Mild	Mild	
Public of use Land	Negligible	Negligible	
Noise Pollution	Negligible	Negligible	
Visual amenity	Negligible	Negligible	

With respect to vegetation, the Four Corners Bore route passes through 21 vegetation associations of which one was unusual and eight were restricted in distribution and it is considered to have moderate conservation value for flora with high flora conservation value where the rail alignment crosses plain/ grassland country. The Eight Mile Well route passes through 13 vegetation associations, of which one was unusual and one was restricted in distribution, and it is considered to have low to moderate conservation value for flora.

The combination of environmental values and impacts to the land holder from the Direct Eight Mile Well route nominates the Four Corners Bore Route as the selected option.

Coondawanna Flats Options

Coondawanna West route compared with Mt Robinson route

The Coondawanna West option passes to the north of West Angela Hill, looping slightly west around Coondawanna Flats then strikes north west towards Packsaddle (Figure 2.2).

The Coondawana West route passes through a significant area of mulga flats with a number of species of conservation interest. CALM have expressed concern that the Coondawana West route would interfere with the surface water flow upon which mulga is reliant resulting in a physical impact to high quality mulga stands. However, this is a management issue which can be dealt with by appropriate drainage structures and culverting.

The Mt Robinson route heads in a north-east direction from West Angelas towards the Great Northern Highway, passing between The Governor and Mt Robinson. The route parallels closely the Great Northern Highway then passes to the west across the northern section of Coondawanna West (Figure 2.2). This route was suggested by the Department of Conservation and Land Management to minimise impact to the Coondawanna Flats area and to create a potential corridor for future mining operations in the region.

Table 2.6 compares the Coondawana West route with the Mt Robinson route using the criteria in Table 2.2 and the information noted in the paragraphs above.

Table 2.6: Coondawanna West option compared with Mt Robinson alignment options

Route	Coondawanna West	Mt Robinson
Length (Km)	30.5	38.0
Maximum Grade - Empty	1.07	0.90
Maximum Grade - Loaded	0.33	0.33
Capital Cost Variance	Preferred	Severe
Operating Cost pa. Variance	Preferred	Medium
Construction Restrictions	Negligible	Negligible
Availability of Construction. Materials.	Medium	Medium
Effect on Surface Hydrology	Severe	Medium
Land Availability	Mild	Mild
Public of use Land	Negligible	Negligible
Noise Pollution	Negligible	Negligible
Visual amenity	Negligible	Negligible

With respect to vegetation, the Coondawana West route passes through 44 vegetation associations of which 13 contained Mulga and 44 were restricted in distribution and it is considered to have moderate conservation value for flora with high flora conservation value where the rail alignment crosses Mulga vegetation. The Mt Robinson route passes 23 vegetation associations of which four have significant conservation value, and it is considered to have moderate conservation value for flora with high flora conservation value where it crossed a seasonal wetland.

The Coondawanna West route has been selected due to its shorter length resulting in considerable savings in both capital and operating costs.

2.3.3 The Selected Rail Alignment

The selected rail route commences by passing to the north of West Angelas Hill, looping slightly west around Coondawanna Flats then strikes north west towards Packsaddle. The route then heads in a west-north-west to meet the rail formation constructed by Hamersley Iron (HI) between Marandoo and Homestead Junction.

From this point, the general route parallels the HI formation within the excised transport corridor which traverses Karijini National Park. The proposed line will dual track the existing HI formation initially on the southern side, crossing the HI line by an overpass located approximately 20 km north-west of the Juna Downs. The line will then dual track the existing HI Marandoo line to the western boundary of the National Park. The Turee Creek system is crossed between the overpass and Marandoo.

Throughout the Karijini section the proposed route is generally within 100-200 m of the HI alignment except where it is necessary to divert around miscellaneous HI leases where separations of up to 600 m occur.

West of Mt Stevenson the preferred rail route leaves the Marandoo spur line and strikes north on the "Four Corners Bore" route option. This route passes to the north of Four Corners Bore, before deviating north-west to meet up with the Hamersley Iron Paraburdoo - Dampier Railway approximately 7 km east of Satellite Spring.

The route then parallels the Paraburdoo - Dampier Railway to the north for approximately 60 km. Most of this section parallels the HI alignment within 100-200m except for about 40 km at the northern end (near Mt Leal) where the rail is located between 400 and 800 m from the HI alignment.

The Mt Leal section diverges from the HI alignment by up to eight kilometres, and for 10 km runs parallel at this distance of separation.

Approximately 2.5 km north of Barowanna Hill, the preferred route heads north onto the "Western" route which roughly parallels the existing Hamersley Iron Railway to the east. The route merges into the Robe Pannawonica - Cape Lambert Railway at a point approximately 3 km north of the Robe River and Hamersley Iron railway's intersection.

The Western Route maintains a 100 m separation for the first 13 km and then diverges up to a maximum of five kilometres for the next seven kilometres. For the next 10 km the distance between the proposed route and the HI track varies between 400 to 1 200 m. The last three kilometres run parallel to the existing Robe railway at a distance of approximately 500 m.

A map of the selected rail alignment appears in Section 3.3 of this ERMP (Figure 3.4) and in Appendix B.

Within the Millstream - Chichester National Park it is anticipated the rail line will be located within a Miscellaneous Licence granted through Robe's State Agreement Act. Use of the licence will avoid

the requirement for excision of segments of the National Park for the rail alignment and will not result in the extinguishment of Native Title for this land use.

2.4 NO DEVELOPMENT OPTION

The consequences of not proceeding with this proposal are that the employment and economic benefits of the proposal as outlined in Sections 2.1.1 and 2.1.2 will not be achieved.

The lump and sinter fines products which will be produced from the West Angelas mine area are of considerably higher quality that the output from current production at Mesa J. As such, West Angelas addresses the current trend and future priorities in blast furnace steel making. Without the ability to respond to those steel making trends, Robe's longer-term viability as a competitive exporter of iron ore must be questioned, with substantial loss of revenue to the State of Western Australia.

3.0 PROJECT DESCRIPTION

3.1 INTRODUCTION

This Chapter gives the details of the West Angelas project, particularly as they relate to the potential environmental impacts associated with the project.

As outlined in Chapter 1, the West Angelas project has essentially three components:

(i) mining of high grade Marra Mamba iron ore deposits in the West Angelas area (initially from Deposits A and B, these having a reported iron resource of 695 Mt);

(ii) transport of this ore for shipping via a railway link between West Angelas and Cape Lambert; and

(iii) an upgrade to the Cape Lambert port facilities.

This Chapter describes the relevant aspects of each of these components. A summary of the proposal characteristics is provided in Table 3.1.

3.2 MINING

3.2.1 Methodology

Robe has identified eight iron ore deposits in the West Angelas project. These Deposits, termed 'A' through to 'H', essentially extend in an east-west direction with the widths ranging from approximately 1.5 km (Deposit A) to 0.2 km (Deposit C). The location of the West Angelas deposits are illustrated in Figure 3.1.

The tonnage of iron resources at each of the Deposits has been measured, with Deposit A having the largest resource with 458 Mt and Deposit G having the smallest resource with 20 Mt. Exploratory drilling on Deposits C to G may increase the total resource available.

The mining at West Angelas will be conducted using conventional open pit methods utilising, large rotary drill rigs, blasting and hydraulic excavators. The mining operation will produce 7 Mt of ore in the first year of operation and should increase to 20 Mt as sales permit.

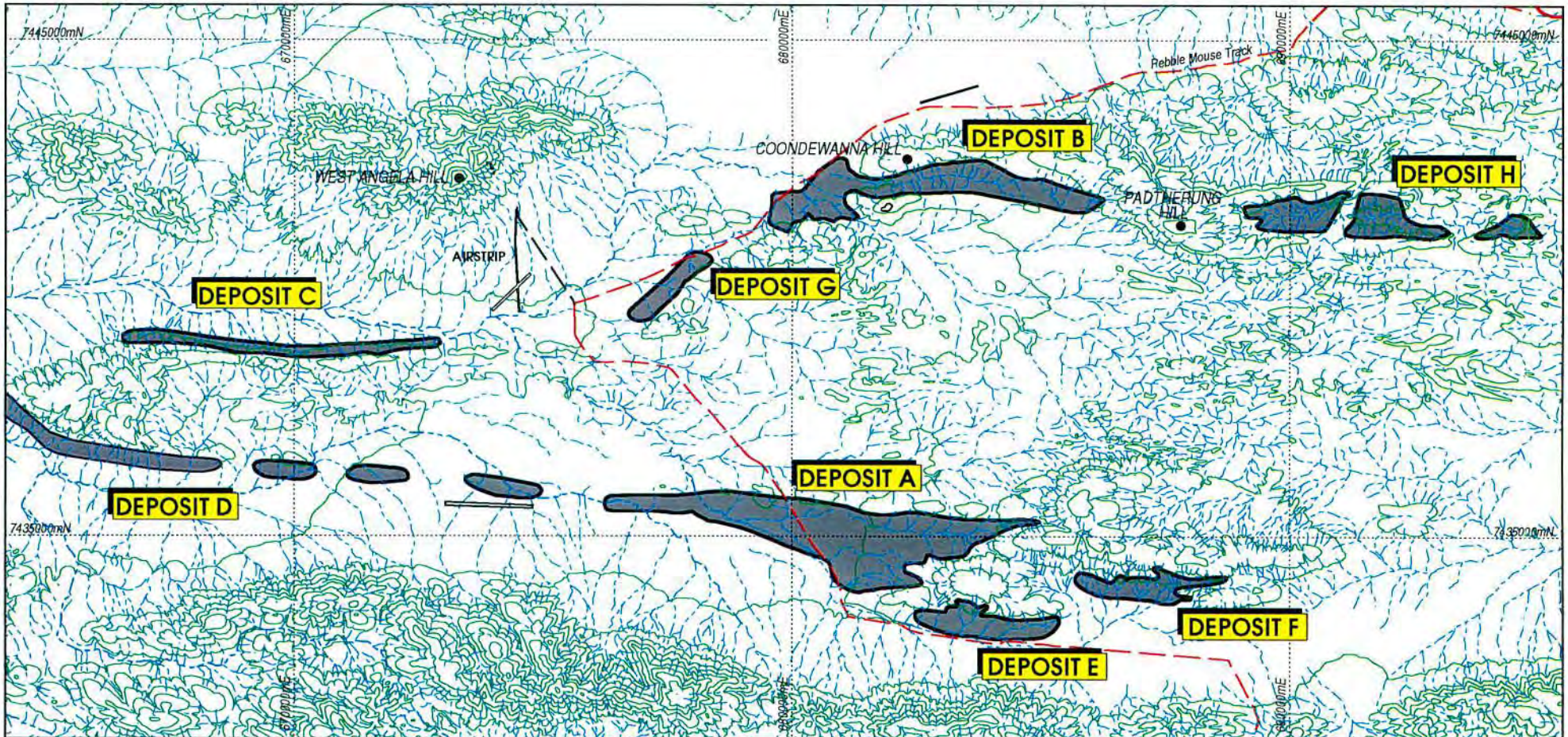
3.2.2 Overburden Management

The open cut mining at Deposits A and B will generate overburden material (unmineralised and low grade material). A life of mine strip ratio has been determined at 2.3 tonnes of waste for every 1 tonne of ore produced. The overburden material will be stored in two waste dumps constructed alongside each open pit, covering an area of 938 and 380 ha respectively for Deposits A and B.

Mine planning will endeavour to maximise placement of overburden inside the mine pit limits as extraction of ore proceeds throughout the mine life, thus minimising further surface disturbance. Upon completion of the mining overburden wastes will be used to cover parts of the mine pit below the natural water table.

Table 3.1: Summary of key characteristics associated with the proposal.

Aspect	Proposal characteristic
Mine	
Ore mining rate	20 Mtpa
Total estimated production (Deposits A & B)	- 450 Mt
Life of project (Deposits A to H)	29 years
Mine pit area	
• Deposit A	460 ha
• Deposit B	335 ha
Maximum depth of pit	
• Deposit A	250 m
• Deposit B	180 m
Area of Overburden Storage	
• Deposit A	850 ha
• Deposit B	600 ha
Dewatering requirements	Minor except after heavy rainfall
Dewatering discharge	Normally to process plant and dust control
Water supply source	Turee Creek B
Water supply requirements	
• Construction	2 ML/day
• Operation	4 ML/day
• Incorporating desliming plant	16 ML/day
Power source	
• Gas pipeline option	46 km
• Overhead powerline option	50.5 km
Transport infrastructure	
• Airstrip	2,300 m runway
• Water pipeline	30 km above ground
Location of mine accommodation village	12 km north-west of mine
Railway	
Length of railway	340 km
Train Movements	22 trains per week (170 cars per train)
Port	340 km
Ship loading	15-20 Mt/a
Reclamation for port stockpile	44.4 ha
Wharf extension	250 m
Workforce (entire project)	
• Construction	1 200
• Operation	450



WEST ANGELAS PROJECT

Topography and Location of Deposits

Figure 3.1

3.2.3 Dewatering

A total of 12 - 15 percent of the mining at Deposit A would be below the water table. However, due to the impermeable nature of the geological strata, the volume of de-watering required is expected to be low. It is proposed that skid mounted sump pumps be utilised for dewatering. However, bores within the pit limits may be used for initial dewatering.

It is expected that rainfall which collects in the bottom of the pit will need to be pumped out. Collected rainfall will be pumped to a holding dam for settling as it is likely that the water would be turbid.

Dewatering water would be mostly used on-site, but in exceptional circumstances such as heavy rainfall events it would be released to drainage channels after detention in the holding dam.

The mined material in this region is predominantly oxidised. Where sulphides have been identified in un-oxidised footwalls they are disseminated and in observed concentrations of less than two percent. Acid mine drainage is therefore not expected to be an issue.

3.2.4 Ore Processing

The layout of the plant has been separated into two distinct locations as follows:

(1) Facilities proposed at Deposit A include:

- primary crushing of Deposit A ore;
- overland conveyor for transport of primary crushed ore to plant;
- secondary crushing and screening common to Deposits A and B crushed material;
- screening and separation into lump and fines products;
- product stockpiling common to Deposit A and B;
- train load-out common to Deposit A and Deposit B lumps and fines;
- facilities for the beneficiation and desliming of fines (currently under investigation); and
- a tailings dam east of the pit area.

(2) Facilities proposed at Deposit B include:

- primary crushing of Deposit B ore; and
- overland conveyor for transportation of primary crushed Deposit B ore.

The initial layout of the crushing and screening facilities at Deposit A will be designed to allow primary crushing of 20 Mtpa of Deposit A ore; and secondary crushing and screening of 20 Mtpa of either Deposit A ore, or 20 Mtpa of combined Deposit A and Deposit B ores

The plant facilities at Deposit B will be designed for the primary crushing of Deposit B ore, to process a maximum of 13 Mtpa, prior to transport of the crushed ore by conveyor approximately 6 km to the facilities at Deposit A. Deposit B is scheduled to be mined 6 - 7 years after mining commences at Deposit A.

The West Angelas crushing and screening plant will be designed to process ore at the rate of 20 Mtpa based on 7,490 operating hours per annum. The products from the plant will be <37.5 mm lump and <6.3 mm fines material, which will be stockpiled separately prior to loading onto trains for transport to Cape Lambert. Stockpile capacity will be at least three days reserve.

For dust control, each of the main ore processing plants (*i.e.* primary and secondary crushing, screening, sampling and load-out facilities) will be equipped with water sprays to minimise dust generation at these points. Additionally, wet scrubbing systems will be provided to extract dust particles that have not been settled by the water sprays.

A schematic flow concept of the mine facilities, and the general mine layout plan are shown in Figures 3.2 and 3.3 respectively.

3.2.5 Ore Transport

For the purposes of this proposal, the capacity of a standard Robe River ore car has been calculated as being 120 t. Based on 331.5 operating days per year and a rail system availability of 90 percent, scheduled railing operations will be a maximum of 22 trains per week, each train composed of 170 cars.

A Long-Airdox bulk loading chute and automatic control system will be used for train loading. A single bin load-out system will be adopted for loading train cars with the ore.

3.2.6 Support Infrastructure

The support infrastructure for mining will include:

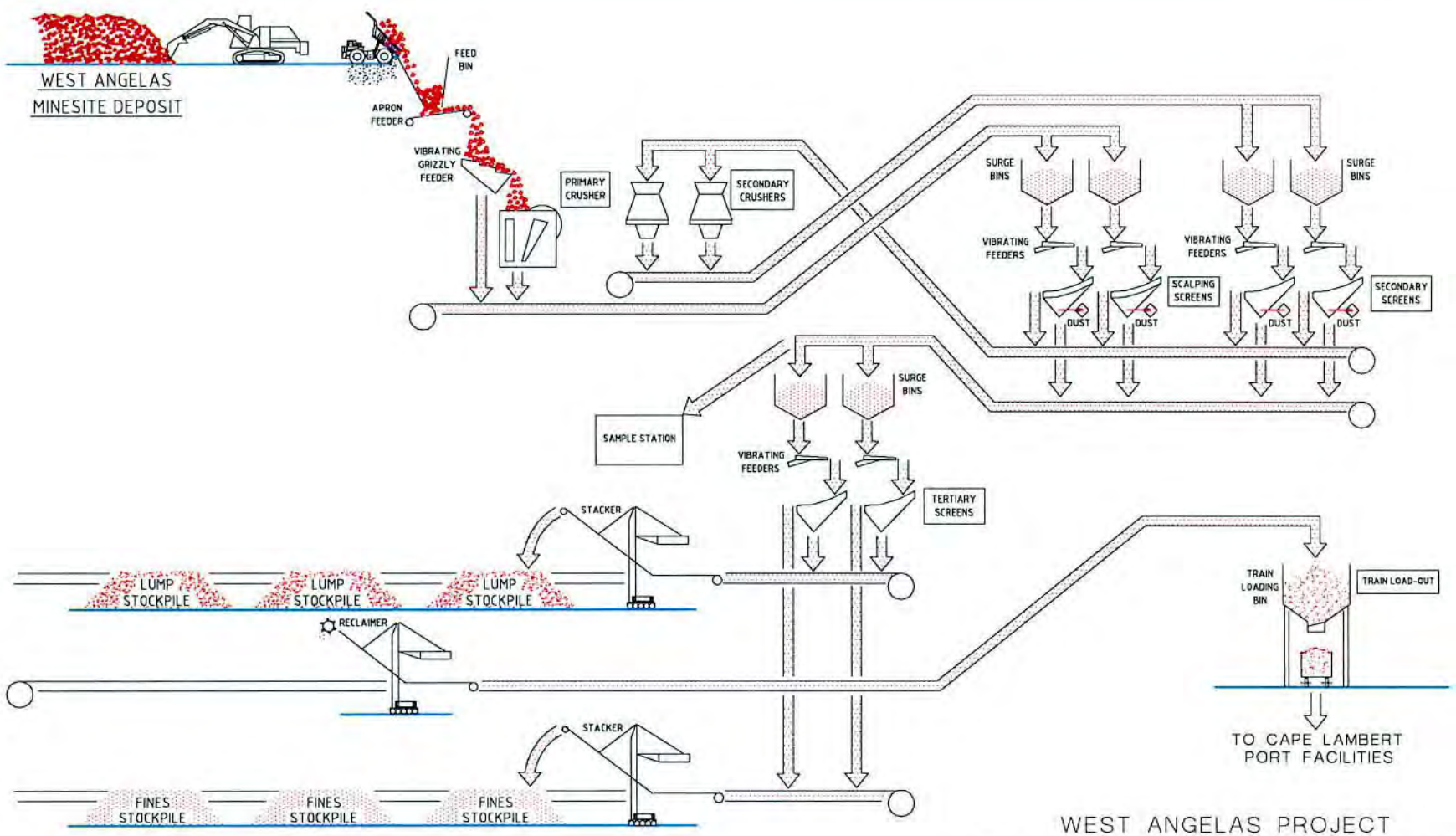
- a private access road to the West Angelas minesite off Great Northern Highway (this will probably be sealed);
- heavy vehicle and plant maintenance workshop and warehouse;
- mine offices;
- radio facilities;
- fuelling and fuel storage facilities constructed to Department of Minerals and Energy requirements;
- vehicle wash down areas;
- village;
- fire tender, ambulance and first aid areas;
- an airstrip; and
- explosives storage facility constructed according to mining regulations.

Gravel will be required for extensions to the airstrip and for construction of access roads in the area of minesite and village. Natural gravels occur abundantly within the area of the mining leases, generally as slopes of sedimentary deposits at the base of the surrounding hills, and all gravel borrow pits will be rehabilitated (See Section 6.2.1 Minesite and roads)

Water Supply

Water requirements for the project (to be sourced from Turee Creek B) are estimated to be:

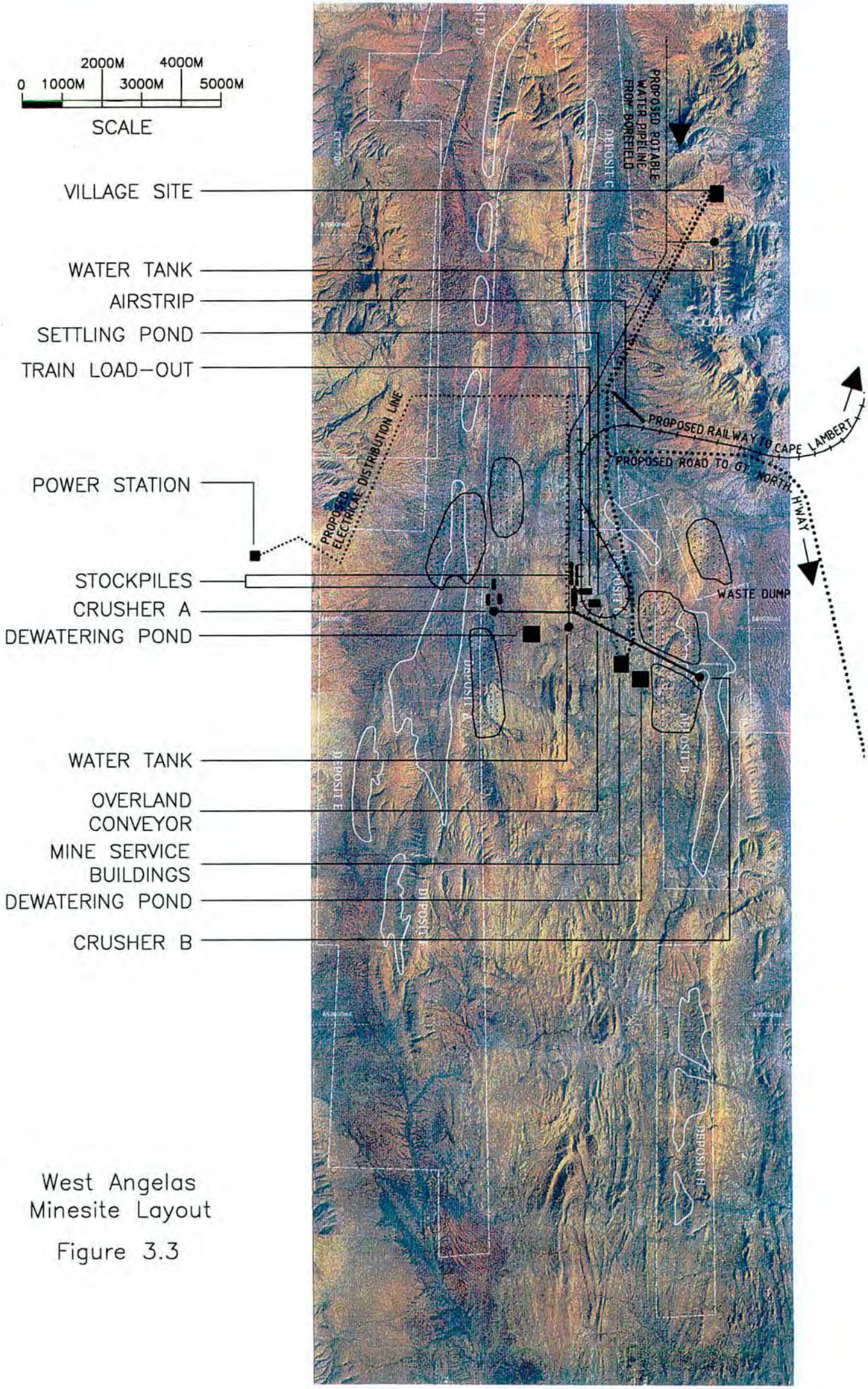
- construction - 2 ML/day
- operating - 4 ML/day
- incorporating desliming plant - 16 ML/day



WEST ANGELAS PROJECT

Minesite Process Flow Diagram

Figure 3.2



West Angelas
Minesite Layout

Figure 3.3

Present indications are that an adequate supply of groundwater for the mine area will be located from Turee Creek B as the aquifer under the minesite has low hydraulic conductivity. Water would be pumped from the source to the mine area in an above ground steel pipeline. An access track would be constructed alongside the pipeline.

Water for the mine will be pumped into a storage tank adjacent to the ore processing plant, and reticulated to mine buildings, crushing, screening and train loading areas. A separate fire service will also be included. The village will have its own storage tank, reticulation and fire service.

Fuel Supply

Fuel will be delivered to the West Angelas mining area by trains from Cape Lambert and stored in bulk fuel tanks located within lined bunds constructed to the requirements of the Department of Minerals and Energy and existing Australian Standards.

Power Supply

The source of power for the project will come from either:

(i) a mine site gas fired power station; or

(ii) an overhead transmission line drawing from that to be built by Pilbara Energy Pty Ltd (PEPL) to serve BHP's Mining Area C and other future projects in the area.

This will be dependent upon competitive power costs being negotiated.

For construction of a gas fired power station at West Angelas, a low pressure gas pipeline would be laid to connect the site to the Goldfields Gas Transmission natural gas pipeline at the Boonanchi Wells valve station. This is located approximately 46 km south-east of West Angelas. The pipeline would be buried for the entire distance.

Should power be supplied by PEPL, an overhead line would connect from the PEPL line at Area C to the West Angelas minesite. This would require 50.5 km of overhead transmission line between the two sites.

At this stage, the gas fired power station and pipeline is the preferred option.

Airstrip

Based on operating needs, it is expected that fly in/fly out personnel will be transported to and from the West Angelas site by light aircraft. This will require upgrading of the existing small airstrip to a standard required for operation of a 50 seat aircraft. A 2,300 m long gravel runway will provide for the carriage of passengers, baggage and freight direct to Perth. The airstrip will also be used for emergency use. It is expected that overburden from the mine will be used as a source of construction material for the airstrip.

3.2.7 Workforce

During construction, the number of personnel working on site is estimated to be up to 1 200 people including up to 450 people in railway construction camps. During operation of the West Angelas mine, approximately 180 persons will be working on-site. The project will operate 24 hours per day, 364 days per year on a basis of two 12 hour shifts. Personnel will be employed on a fly in/fly out basis. Fly in/fly out is now the best option for mining operations due to: (i) the current FBT taxation arrangements; (ii) it avoids up-front capital costs associated with building a townsite and associated infrastructure; and (iii) it can be responsive to changes in workforce number requirements.

Accommodation for employees will be provided in a village to be constructed at the base of the West Angelas hills (Figure 3.3). A separate temporary camp will be utilised for construction contractors. The accommodation village will include typical mess and recreation facilities for remote mine sites.

3.3 RAILWAY

Robe presently operates the 200 km long Pannawonica Railway, which links Cape Lambert to their mining operations at Pannawonica. Development of the West Angelas deposit will require the construction of a new, single standard gauge rail line between the West Angelas mining area and Robe's crushing and ship loading facility at Cape Lambert. A rail loop is to be constructed at the West Angelas mine.

As per the Pannawonica line, construction will be of 68 kg continuous welded rail set on concrete sleepers, to carry 36 tonne axle loads. Travel time between the West Angelas minesite and Cape Lambert will be 7.5 - 8 hours in each direction.

The selected route for the West Angelas railway is described in Section 2.3.3 and is shown on Figure 3.4 and in Appendix B.

Within the Millstream Chichester National Park, the rail line will be located within a General Purpose Lease under the Mining Act, 1978. Use of a General Purpose Licence will avoid the requirement for excision of segments of the National Park for the rail alignment.

Railway access roads are not public roads and will be blocked using a combination of barriers and a locked gate.

3.3.1 Borrow Areas

All material borrow areas will be within a one kilometre rail route corridor. Borrow pits may be located within the corridor through the National Park access and the existing management procedures will be applied.

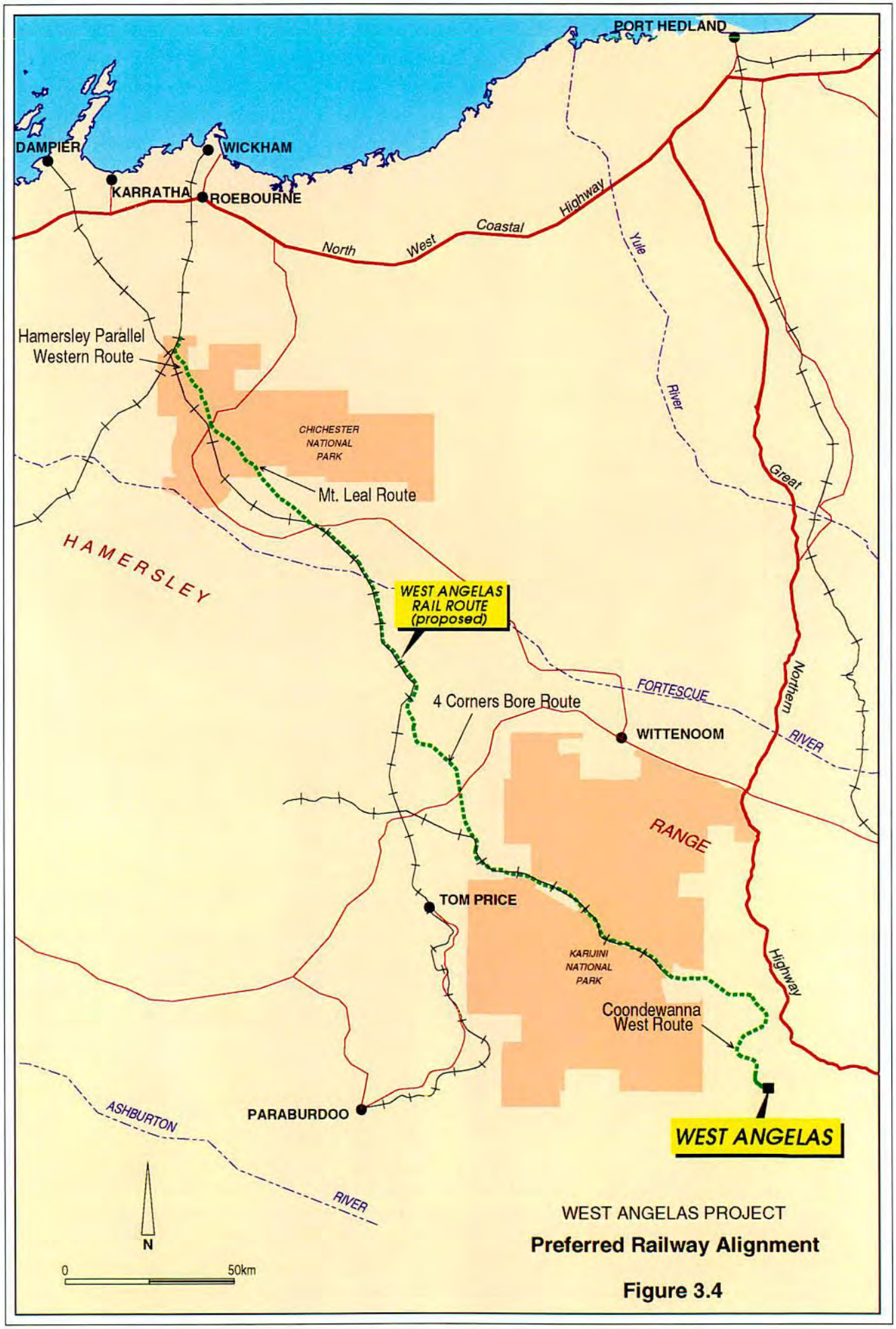
Robe's existing environmental management procedures for borrow pits will apply to all borrow pits along the new railroad. These procedures include:

- borrow pits to be located at least 150 m from any public roads, will have their axis parallel to any nearby roads and to have a single access road;
- borrow pits will be located at least 50 m from any watercourses; and
- rehabilitation when the facilities are no longer required.

In addition to the above procedures, borrow areas will be closely spaced where possible to minimise the volume of material removed from each area. Additionally, where possible the borrow areas will be adjacent to the proposed rail line.

3.3.2 Quarries

There will be one or at the most two quarries along the rail route for the supply of track ballast and concrete aggregates. Provided there is sufficient stone, the existing '10 KP' quarry at Cape Lambert will be expanded and a concrete sleeper manufacturing plant temporarily constructed adjacent to the site for a period of two years.



WEST ANGELAS PROJECT

Preferred Railway Alignment

Figure 3.4

A second quarry is likely to be established near the T-junction of the Hamersley - Mt Bruce Road and the Wittenoom-Nanutarra Road, which is near Hamersley Iron's new Hill D quarry.

An exploration lease is currently being sought for a 2 km by 6 km area until the extent of the quarry can be defined, at which time a mining lease of lesser area will be applied for.

Quarry sites will be retained as a source of ballast aggregate for maintenance of the track over the life of the project.

Appropriate approvals will be sought for ballast quarry sites.

3.3.3 Construction Camps

It is proposed that construction camps would be established during the rail construction phase at about 100 km intervals. Camps would be located near existing HI camps or at abandoned HI construction camp areas. Four sites have been selected at:

- near Python Pool on station property;
- near Camp Anderson on the Hamersley Iron rail line;
- near the Hill D quarry site; and
- near the BHP Packsaddle camp.

Camps for between 100 and 450 people would be constructed using transportable buildings. A permanent rail maintenance camp is not contemplated at this time as it is intended that track crews will be equipped with mobile camps or work from Cape Lambert or the West Angelas mine.

3.4 CAPE LAMBERT PORT EXPANSION

3.4.1 Introduction

To allow for the train unloading, product stockpiling and shipping of the West Angelas ore, the Cape Lambert Port facility will require an expansion. The expansion is expected to include a new shiploader, an extension to the existing jetty, some dredging, and some modifications to existing facilities. The facility currently utilises a single shiploader for two berths. In 1995/96, 185 ships were loaded at Cape Lambert. With increased export volumes from West Angelas ore 397 ships per year are anticipated.

A second shiploader would be constructed when port capacity demands, thereby lifting the ship loading capacity of the facility to approximately 45 - 50 Mt/a. When the volume of exported ore is greater than 45 - 50 Mt/a, the port would be expanded to provide for the berthing of four ships. This would require an extension of the existing wharf head by approximately 250 m.

The concept at the Cape Lambert site includes:

- emptying ore cars via a new train car dumper;
- transport by conveyor of either lumps or fines product to separate lumps or fines stockpiles:
- reclamation of lump and fines product for ship loading. Lump product is re-screened prior to ship loading, with the <6.3 mm fines conveyed back to the fines product stockpiles for blending of recovered fines to maintain sinter fines quality consistency.

The structures proposed to be constructed on the land portion of the Cape Lambert facility, as part of the West Angelas project, are:

- rotary ore car dumper;
- power substations;
- a product stockpile pad;
- a tertiary screening facility; and
- new rail and plant control and maintenance facilities.

3.4.2 Stockpile Extension

The increased rate of ore shipping will require the construction of an additional product stockpile pad area. The extra pad will comprise a northern extension into the sea paralleling the existing facility. This will require the construction of a new sea wall and reclamation of approximately 44.4 hectares of land (Figure 3.5).

The new sea wall will be built to the same design as for the previously reclaimed area, as shown in Figure 3.6. This design is adequate to cater for 1:50 year wave and surge conditions. Modelling has shown that its stability is not sensitive to changes in water levels. This design was accepted as satisfactory for clearance of a Works Approval condition for construction of the Cape Lambert Stockpile Revetment by the Department of Environmental Protection in 1992.

Rock armour for the northern revetment will be taken from Robe's existing quarry. Due to the quantity of large armour required, it may become necessary to expand the area of the existing quarry lease.

Some of the fill required for bulk earthworks at Cape Lambert will be obtained from sand dunes and a hill which lie adjacent to the proposed stockpile area. The sand dunes and hill lie within the Cape Lambert lease area (see Figure 3.5). The location of the fill source to completely fill the reclaimed area is yet to be confirmed. It may consist of mine waste material. Any proposal to use materials for fill which are not sourced from sites with existing approvals or from the mine will be referred to the Environmental Protection Authority.

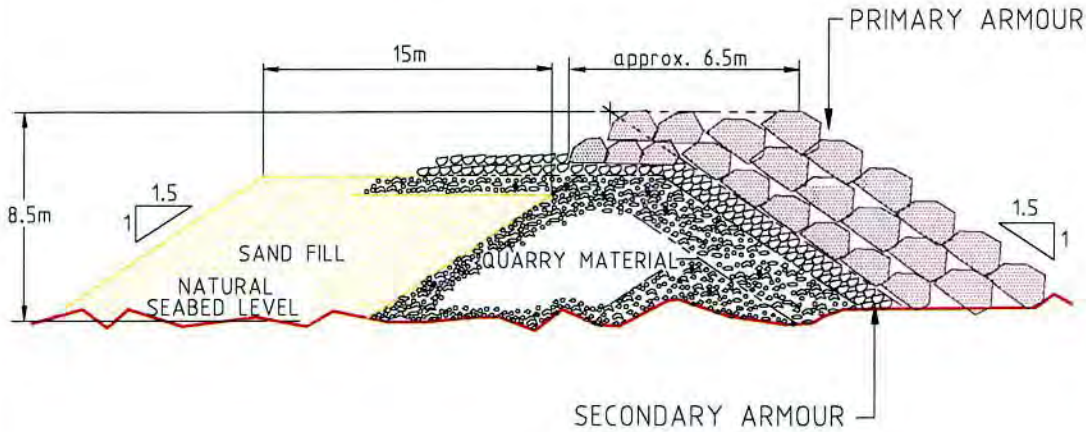
3.4.3 Wharf Extensions

The existing wharf is a 281 m long open pile structure with 2 341 m long finger pier supporting a 1.52 m wide conveyor and light roadway. The eastern berth is 18.5 m deep and the western berth is 19.8 m deep. The Cape Lambert departure channel was deepened in 1984 to 16 m deep, 220 m wide and 18.2 nautical miles long (Robe, 1997a).

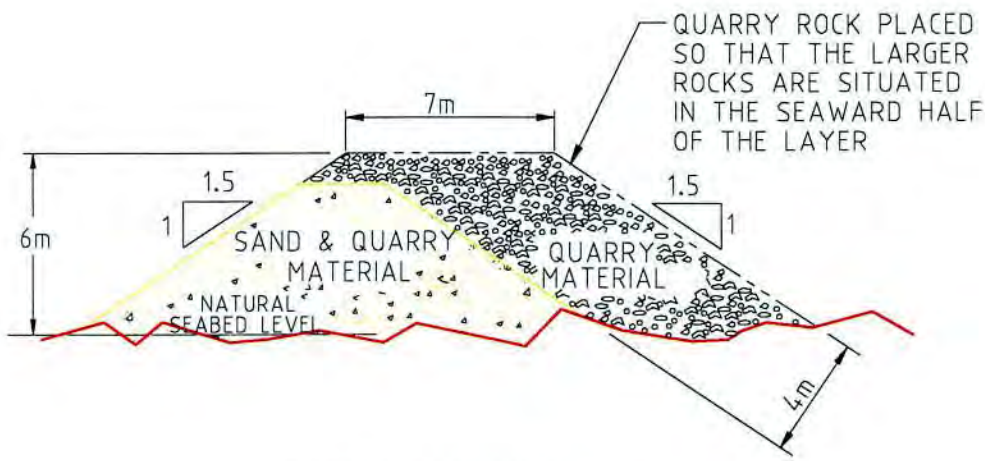
In order to facilitate the installation of a new shiploader and jetty conveyor, it will be necessary to extend the existing wharf about 250 m seaward. This will make maximum use of the existing berths and for parking of one shiploader whilst leaving optimum travel space for the other shiploader to load ships. The extensions would accommodate the berthing of > 230 000 DWT vessels.

Stockpile Reclamation Area

Figure 3.5



NORTHERN REVETMENT WALL



EASTERN REVETMENT WALL

WEST ANGELAS PROJECT

New Revetment Walls Construction

Figure 3.6

Dredging will also be required for deepening and widening of the departure channel on both sides of the wharf over a distance of over 1 km seawards from the new wharf head. The berthing area would be extended and deepened to provide the two new berths with a depth of 20 m below the mean water level.

Dredging volumes of 590,000 m^3 have been estimated from preliminary engineering studies. Dredge spoil will be disposed of on sites which have previously been used for spoil disposal (see Figure 3.8).

The proposed extension of the ore wharf, the development of the two berths and associated dredging is illustrated in Figure 3.7.

3.4.4 New Shiploader

A new 10,000 t/h rated slewing/luffing shiploader will be provided and located to the seaward end of the ore wharf. The loader will be designed to load iron ore into ships varying in capacity up to a nominal 300,000 DWT at a maximum loading rate of 10,000 t/h.

Concurrent with the installation of the new shiploader will be the installation of a new jetty conveyor rated at approximately 10,000 t/h.

3.4.5 Other Associated Facilities and Modifications Required

Modifications would be required to the existing shiploader to effectively handle West Angelas lump and fines. The existing jetty conveyor and reclaim conveyors, and sample plant equipment would also require some modification.

A new ship loading sample plant would be established to provide sampling facilities for West Angelas products.

3.4.6 Power

The estimated total load for the new facilities at Cape Lambert will be about 7 MW which will be supplied from the existing Cape Lambert power station, which is currently operating below capacity.

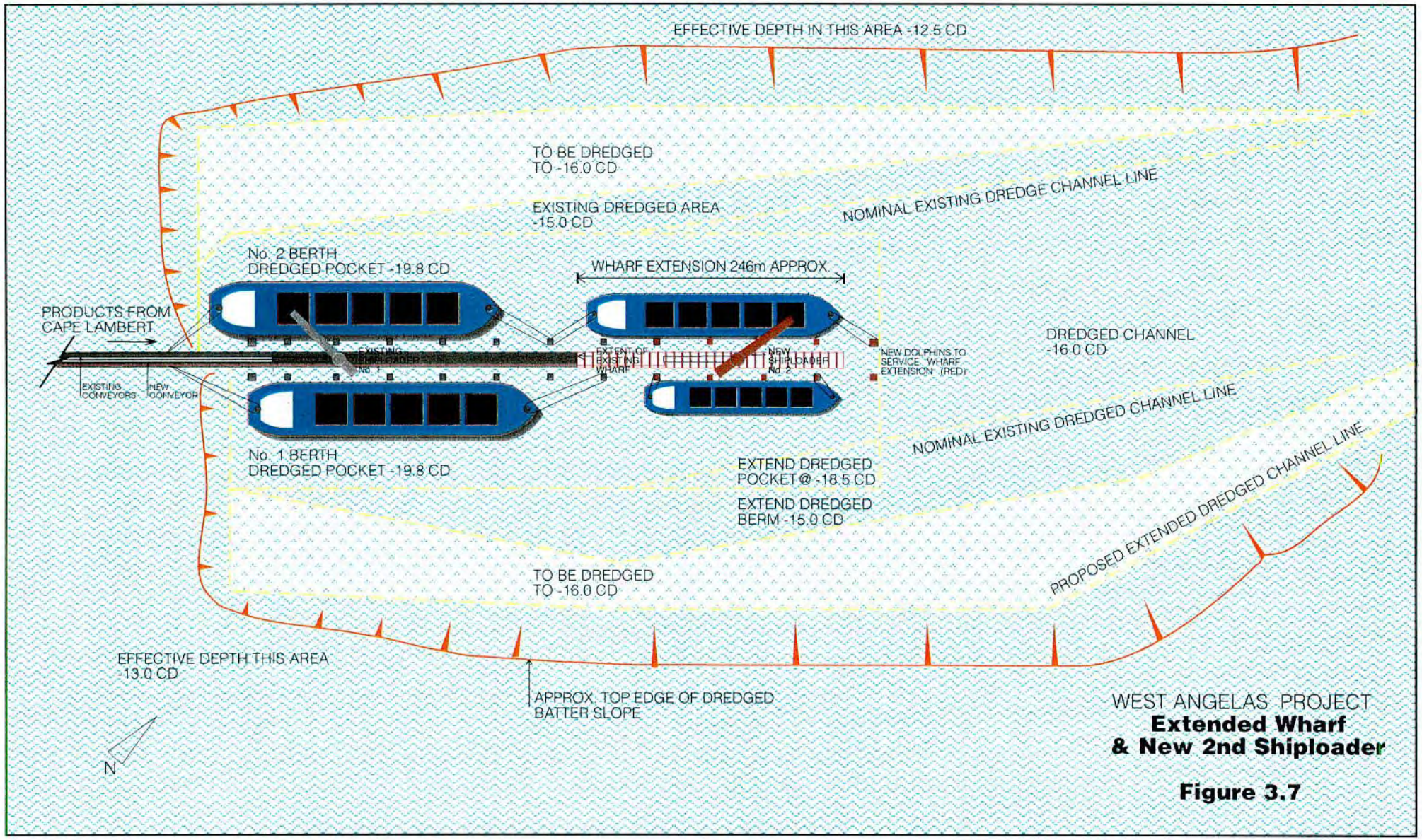
New power and service distribution systems will be provided for each of the new facilities.

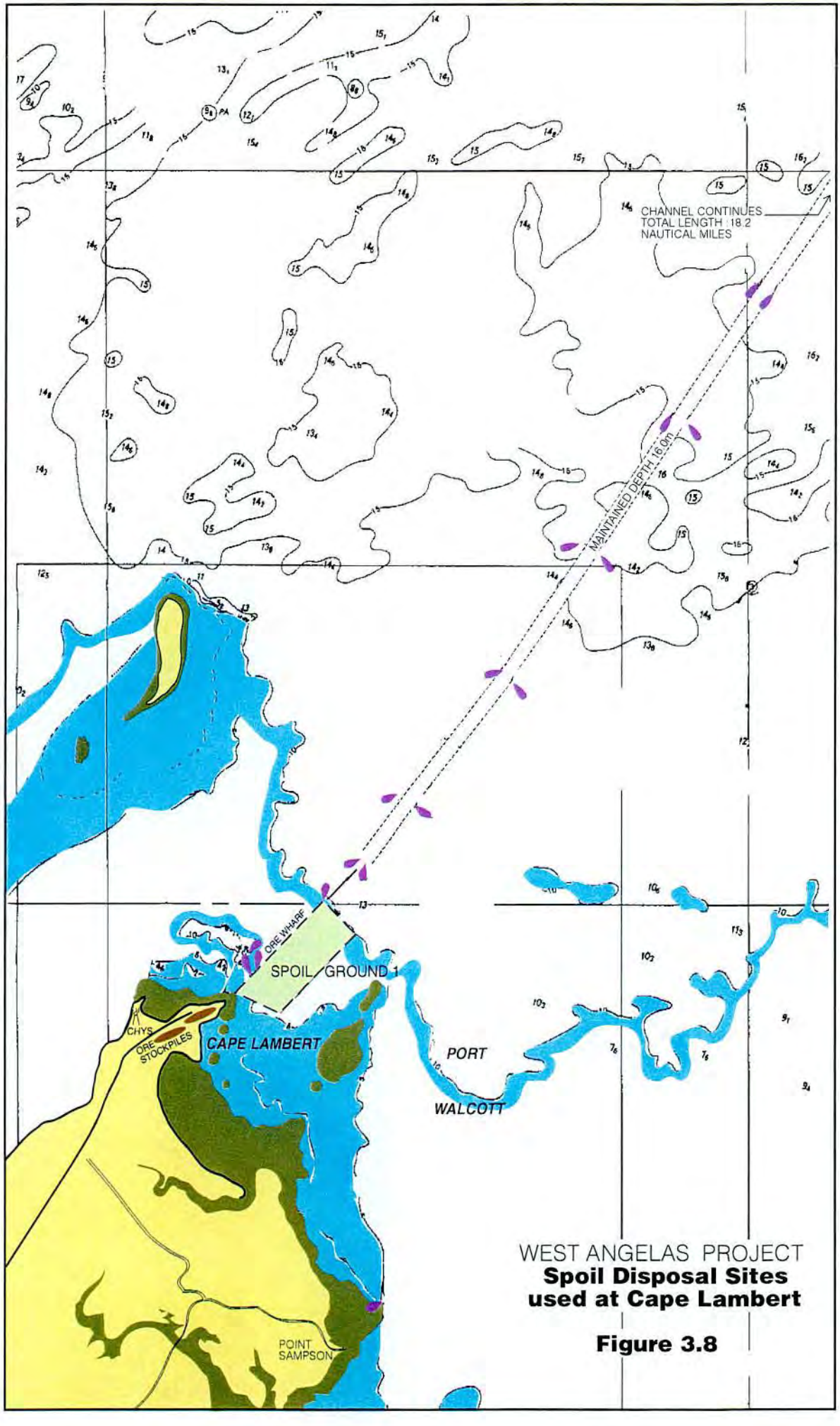
3.4.7 Workshops at Cape Lambert

The existing Cape Lambert plant workshop and warehousing facilities will be expanded to cater for the increased plant activities.

Similarly, the locomotive and ore car maintenance workshop and services will be expanded or modified to accommodate the increased rail haulage requirements resulting from West Angelas Operations.

In addition, a new rail administration office and associated facilities will be required to service the enlarged rail operations.


EFFECTIVE DEPTH IN THIS AREA -12.5 CD
TO BE DREDGED
TO -16.0 CD
EXISTING DREDGED AREA
-15.0 CD
NOMINAL EXISTING DREDGE CHANNEL LINE
No. 2 BERTH
DREDGED POCKET -19.8 CD
WHARF EXTENSION 246m APPROX.
PRODUCTS FROM
CAPE LAMBERT
EXISTING
SHIPLOADER
No. 1
EXTENT OF
EXISTING
WHARF
NEW
SHIPLOADER
No. 2
NEW DOLPHINS TO
SERVICE WHARF
EXTENSION (RED)
DREDGED CHANNEL
-16.0 CD
EXISTING
CONVEYORS
NEW
CONVEYOR
No. 1 BERTH
DREDGED POCKET -19.8 CD
NOMINAL EXISTING DREDGED CHANNEL LINE
EXTEND DREDGED
POCKET @ -18.5 CD
EXTEND DREDGED
BERM -15.0 CD
PROPOSED EXTENDED DREDGED CHANNEL LINE
TO BE DREDGED
TO -16.0 CD
EFFECTIVE DEPTH THIS AREA
-13.0 CD
APPROX. TOP EDGE OF DREDGED
BATTER SLOPE
N
WEST ANGELAS PROJECT
Extended Wharf
& New 2nd Shiploader
Figure 3.7



WEST ANGELAS PROJECT

Spoil Disposal Sites used at Cape Lambert

Figure 3.8

4.0 PUBLIC CONSULTATION PROGRAMME

Robe has undertaken consultation directly with a range of government agencies including local shires, the Conservation Council of Western Australia, affected landholders and other mining companies with an interest in the proposal. Robe also provided opportunities for members of the public to comment on the proposal. These opportunities were provided in addition to those already provided by the DEP/EPA processes.

The following government agencies, landholders, mining companies and community groups were consulted in the formative stages of the proposal.

State and Local Government

Department of Conservation and Land Management
Department of Conservation and Land Management Marine Turtle Program
Department of Land Administration
Department of Resources Development
Water and Rivers Commission
Water Corporation
Shire of Ashburton
Shire of East Pilbara
Shire of Roebourne

Community groups

Conservation Council of WA

Mining companies

Acclaim Exploration N L
Armico Mining Pty Ltd
BHP Minerals Pty Ltd
Hamersley Iron
Stockdale Prospecting Ltd

Pastoral leases

Coolawanya Station
Hamersley Station
Juna Downs Station
Malina Station
Turee Creek Station

The DRD has had a coordinating role with respect to government agencies, and key agencies such as CALM were consulted directly.

Robe placed advertisements in the print media in the West Australian (Monday 22 September), Geraldton Guardian (Monday 22 September), and North West Telegraph (24 September) inviting people to view displays located in either the Shire office or library at Newman, Tom Price, Karratha and Roebourne, and to comment on the proposal. The displays were available for viewing over a four week period at each location commencing the last week of September 1997.

At the displays, copies of an A4 brochure describing the project were freely available for people to take. The public were invited to comment direct to Robe either in writing, by telephone or by E-mail on the West Angelas proposal. The number of people who viewed the display is unknown, although all sites reported interest in the project and collection of brochures by people viewing the display. All displays remained at the sites for some time.

All directly affected pastoral stations were sent a copy of the project EPA Referral Summary Document and a copy of the A4 brochure.

The Summary Document was also sent to any members of the public inquiring about the project. During the public consultation period, a total of three persons made direct contact with Robe representatives, with all of these being interested in potential employment prospects.

Aboriginal spokespersons for the Bunjima Niapaili Innawonga, Ngaluma, Injibandi, Gorawarrah Mininindrah and Guruma people have been extensively consulted regarding issues concerning Aboriginal heritage and Native Title. Robe will be involved in discussions with all relevant Native Title claimants and the State Government in accordance with the Native Title Act, 1993.

PART TWO

THE ENVIRONMENT

5.0 DESCRIPTION OF RECEIVING ENVIRONMENT

5.1 CLIMATE

The climate of the Pilbara is classified as arid-tropical with two distinct seasons; a hot summer extending from October to April and a mild winter from May to September (Gentilli, 1972). The Pilbara region is influenced by two main rainfall systems; the northern rainfall systems of tropical origin and the southern winter rainfall systems. This results in a bi-modal rainfall distribution (Figure 5.1). The first peak occurs during January to March as a result of moist tropical systems, derived from the north. The second smaller peak, occurring between May to June, results from extensive cold fronts moving across the south of the State in an easterly direction, and occasionally extending into the Pilbara.

There are three basic mechanisms that result in heavy rainfall in the Pilbara:

(i) tropical cyclones;

(ii) monsoons; and

(iii) north-westerly epitropical flows (Gentilli, 1993).

Tropical cyclones, usually between January and April, contribute the majority of the rainfall.

A major feature of the rainfall is the unreliability and variation in annual recordings (Muir, 1983). The capricious nature of the rainfall is of biological significance. While the sporadic summer rain storms are intense, prolonged and efficient for plant growth, the light winter rains are ineffective for growth, except for herbs and grasses (Milewski, 1981). Due to the low rainfall and brief wet season, watercourses flow, if at all, for only brief periods. However, surface water remains available all year round in some river pools, waterholes and springs.

Within the Pilbara, the temperature range is large and maxima are high. Summer temperatures may reach as high as 49°C, with a mean maxima of 30°C, while winter temperatures generally have a mean maxima of 23°C (ranging from 14 - 35°C). Light frosts occasionally occur during July and August. The heat experienced throughout the year is usually very dry as high temperatures and humidity seldom occur together.

At West Angelas, average monthly rainfall data and temperature data was collected during the periods 1977 - 1980 and 1977 - 1978 respectively (Figure 5.1).

The mean daily maximum temperature ranges from 20.9°C in July to 36.9°C in December (Figure 5.1). July has the lowest mean daily minimum temperature at 9.8°C, while January has the highest at 24°C. The average annual rainfall is 430 mm (Robe, 1996). The meteorological data for West Angelas is similar to that as recorded by the Bureau of Meteorology (1995) for Newman.

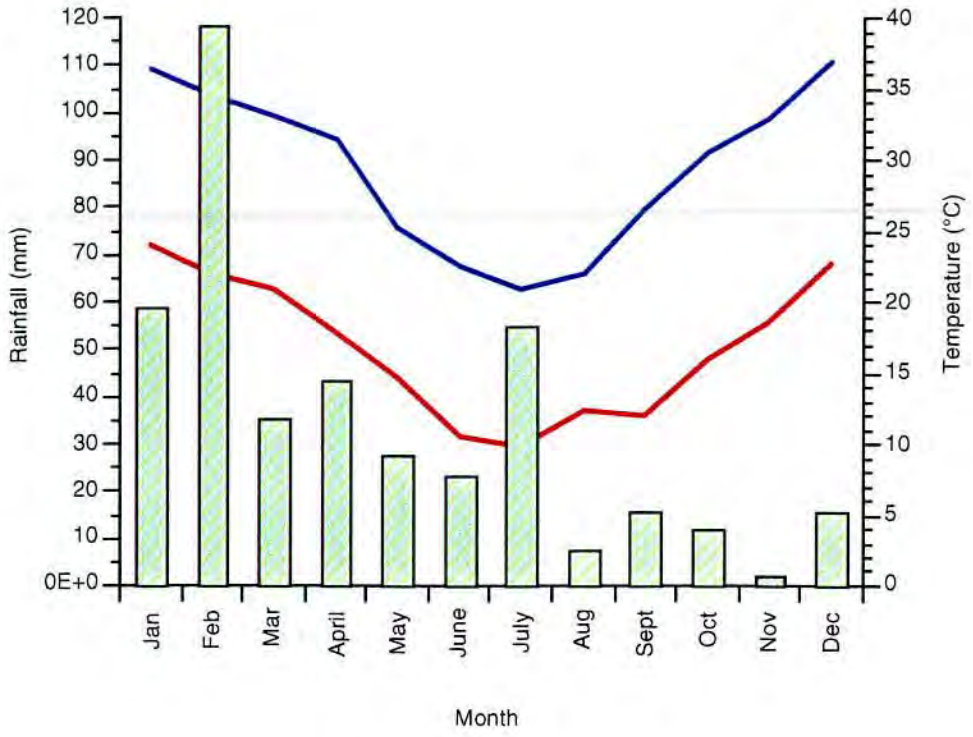


Figure 5.1: Mean monthly maximum and minimum temperatures and rainfall for West Angelas
Figure adapted from: Robe (1996)

5.2 PHYSIOGRAPHY

The topography varies significantly along the rail route between Cape Lambert and West Angelas,.

Within the West Angelas area the Marra Mamba Iron Formation outcrops as low to moderate relief hills and ridges. The topography is generally a gentle slope on the dip slope of the ridges and hills. The highest point within the mining leases is Padtherung Hill (at 969 m ASL) between Deposits B and H. The surrounding plains average approximately 700 m ASL (Robe River Iron Associates, 1996).

The Brockman Iron Formation occurs as the high relief east-west trending Brockman Range. The maximum height within the Range is 1 191 m ASL, while West Angela Hill to the north is 1 012 m ASL.

Scree slopes occur at the bases of the Marra Mamba and Brockman iron formation ridges, which are separated by Quaternary alluvial sheet-wash plains.

The proposed West Angelas village site is located near the top of the gentle slopes (at about 730 m ASL) that surround West Angelas hill.

5.3 GEOLOGY

5.3.1 Regional Geology

The Pilbara Region comprises a large part of the ancient continental shield of Western Australia that is comprised of both Proterozoic and Archaean rocks. The latter constitute a block known as the

Pilbara Block which is overlain by the Proterozoic deposits in the Hamersley and Bangemall Basins. The Hamersley Basin which occupies most of the southern part of the Pilbara Block and can be divided into three stratigraphic groups; the Fortescue, Hamersley and Turee Creek Groups (Beard, 1975; Jarvis, 1979).

Of the three stratigraphic groups, the Fortescue Group is the oldest component, resting upon a granite and greenstone basement. It consists mainly of basalt with included beds of siltstone, mudstone, shale, dolomite and jaspilite. This group forms the Chichester Plateau and underlies the Hamersley Plateau. The Hamersley Group consists predominantly of jaspilite and dolomite, the former giving rise to deposits of haematite and limonite which are now worked as iron ore. These rocks constitute the Hamersley Range and Plateau. The Turee Creek Group is the youngest and is exposed mainly in the Ashburton Valley. It is composed of interbedded mudstone, siltstone, sandstone, conglomerate and carbonate (Tyler *et al.*, 1991; O'Brien and Associates, 1992).

Of the three groups, the Hamersley Group is the most relevant to this proposal. Generally 2.5 kilometres thick, it contains both the Brockman Iron Formation and the Marra Mamba Iron Formation, which together with the Robe Pisolite (Tertiary) provide most of the known major iron ore deposits in the Pilbara region (O'Brien and Associates, 1992). For example, iron ore deposits at Mount Tom Price, Mount Whaleback and Paraburdoo are derived from the Brockman Iron Formation, while the Marra Mamba Iron Formation comprises the Marandoo, Area C and Hope Downs ore deposits.

5.3.2 West Angelas Project Area

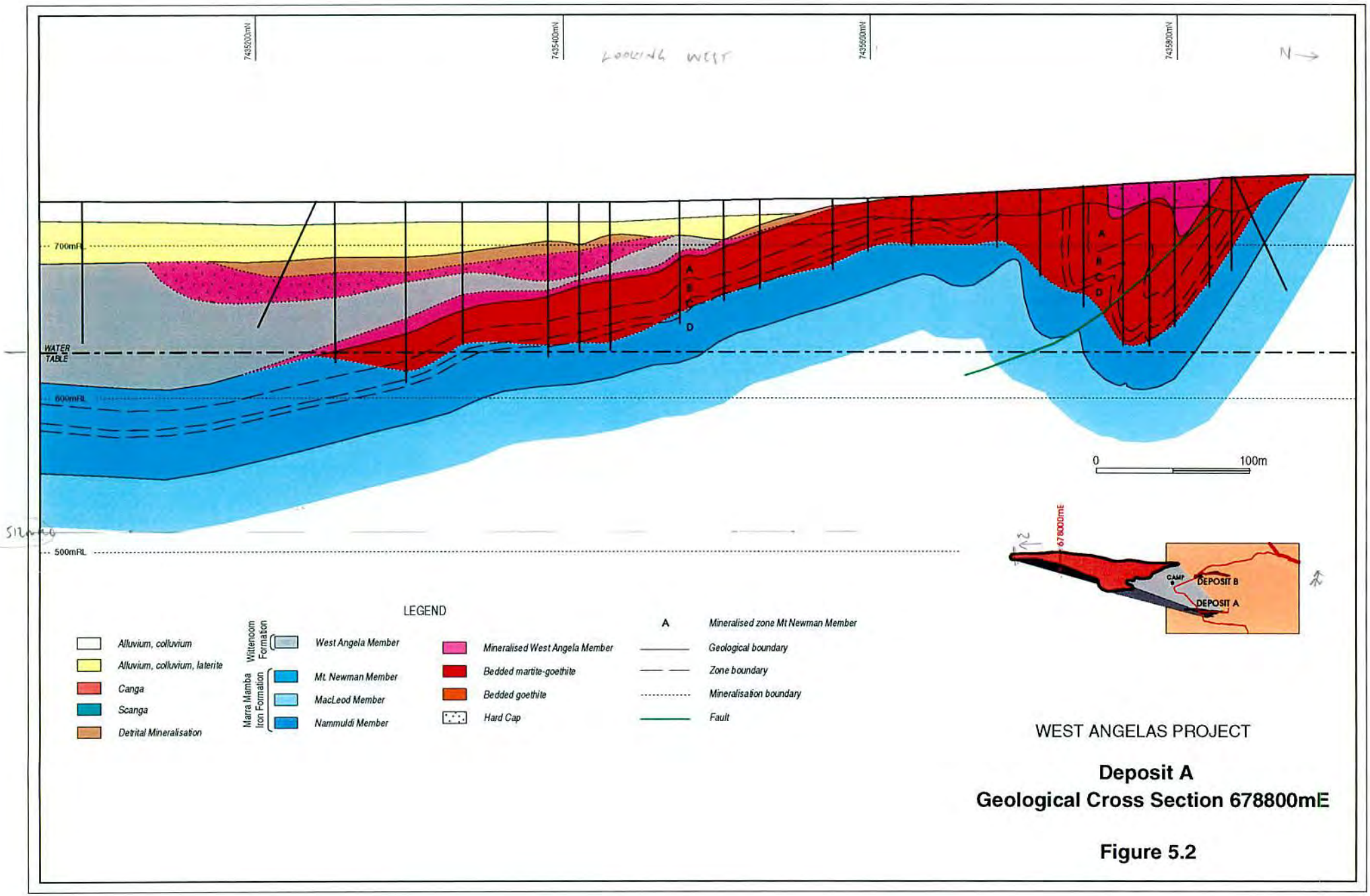
The geology of the West Angelas area consists of a west plunging anticline of Marra Mamba Iron Formation. The anticline is the western extremity of the Wonmunna Anticline. Structurally, this anticline is paralleled both to the north and south by synclines of Brockman Iron Formation overlying lesser outcrops of the Mt McRae Shale, Mt Sylvia Formation and Wittenoom Formation.

The Marra Mamba Iron Formation is subdivided into three members. Economically, the most important unit of the Marra Mamba Iron Formation is the uppermost Mt Newman Member which hosts the majority of the mineralisation at West Angelas. Mineralisation consists of a series of discontinuous deposits located on both the north and south limb of the regional anticline. Along the northern limb (from east to west) are Deposits H, B, G and C, while the southern limb hosts (from east to west) Deposits F, E, A and D.

Deposit A

Deposit A is situated on the southern limb of the Wonmunna Anticline, with mineralisation occurring within a second-order syncline, plunging to the west. The iron enrichment is confined to the upper two-thirds of the Mt Newman Member, with minor mineralisation in the lower six metres of the West Angelas Member of the Wittenoom Formation (Figure 5.2). The deposit is approximately six kilometres long, along strike, and 1.5 kilometres wide across strike.

Asbestos (crocidolite) has been encountered within drill holes, occurring within the Vivash Riebeckite Zone which straddles the lower part of the Mt Newman Member and the upper portion of the MacLeod Member of the Marra Mamba Iron Formation.



WEST ANGELAS PROJECT

Deposit A
Geological Cross Section 678800mE

Figure 5.2

Deposit B

Deposit B is located within a second-order syncline on the northern limb of the Wonmunna Anticline, approximately 7 km north of Deposit A. Much of the deposit in the east is outcropping as the syncline has a steeply dipping south limb. The syncline plunges to the west, and consequently the Marra Mamba Iron Formation is covered by Tertiary and Quaternary sediments in the west. The deposit is approximately 6.5 km long and averages 350 m in width. Mineralisation occurs within the upper half of the Mt Newman Member, with minor enrichment of the lower portion of the overlying West Angelas Member of the Wittenoom Formation (Figure 5.3).

Deposits C - H

Deposits C - H at West Angelas contain a total measured mineral resource of 251.3 Mt. Deposit C is the largest of these six deposits, accounting for approximately 40 percent of their measured mineral resource. In addition, the eastern portion of Deposit D has an indicated mineral resource of 80 Mt.

5.4 SOILS

Soils of the Pilbara region have been defined and mapped at the 1:2 000 000 scale by Bettenay *et al.* (1967). The dominant soil types covering the project area are shallow coherent and porous loamy soils with weak pedologic development.

In the hills and rock ridges, which represent the surface expression of the Marra Mamba Iron Formation, extensive areas without soil cover occur,. Those soils which do occur are shallow and skeletal. Rocks of the Formation weather very slowly, and any soil which does form tends to be transported into the surrounding valleys and plains as a result of the sparse vegetation cover and erosion force of heavy rains derived from thunderstorms and cyclones (Beard, 1975).

The soils on slopes, although having had more time to develop than the soils of the adjacent ridges, are still influenced by the parent rock and may be shallow and stony sands or loams. These soils are generally unfavourable for plant growth due to a low moisture holding capacity and poor nutrient status (Beard, 1975).

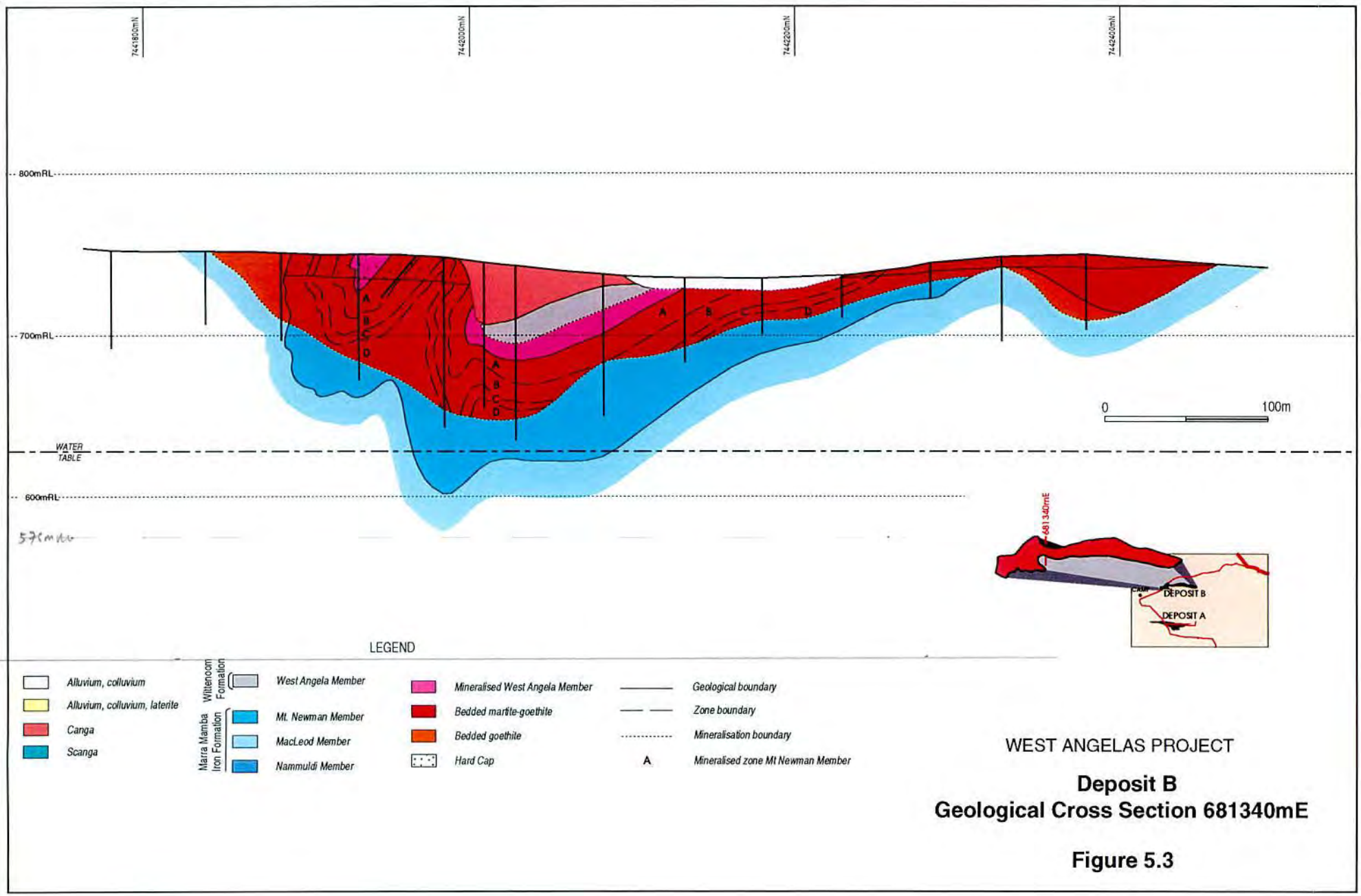
On pediments, older pediplains and alluvial plains, hard alkaline red loamy soils tend to be dominant, and may be considered as the regional mature soil type (Beard, 1975). The surface of these areas may carry a layer of small gravel which is derived from the more resistant rocks in the area.

5.5 GROUNDWATER

5.5.1 Regional Hydrology

Investigations undertaken by Woodward-Clyde indicate that there are two groundwater systems in the region, both of which drain east to west. The northern-most system drains from the West Angelas/ Karijini area, with an aquifer occurring within an alluvial sequence between 65 - 120 m below the surface. The southern system drains catchments to the south of a high-standing east-west oriented Brockman anticline. The aquifer occurs within an alluvial and scree sequence occurring between 50 - 130 m below the surface.

Much of the groundwater for this proposal is to be sourced from the Turee Creek (B) area where the groundwater is 40 - 50 m below the surface. The water from bores at Turee Creek (B) bores is a magnesium Bicarbonate-type water, indicitive of juvenile groundwater, consistent with active groundwater recharge and throughflow.



WEST ANGELAS PROJECT

Deposit B
Geological Cross Section 681340mE

Figure 5.3

5.5.2 Deposit Hydrology

Both the orebodies at Deposit A and B extend below the water table. Approximately 15 percent of Deposit A ore body is below the water table. At Deposit A, the water table occurs at 630 m RL and at Deposit B 628 m RL.

5.6 SURFACE WATER

5.6.1 Regional Hydrology

The Pilbara is a biogeographical region characterised by low and episodic rainfall. Streams of this region are therefore generally ephemeral and non-cyclical. However, the permanent river-pools of the Pilbara, typified by systems such as Millstream on the Fortescue River, are considered the most important environmental features of the region. These permanent pools are a refuge for aquatic fauna which re-colonise other, previously dry reaches of rivers during periods of increased flow. Similarly, permanent pools are a focus, both as habitat and as a food resource for terrestrial fauna and birds. Given the significance of these water bodies, the maintenance of both adequate biological water quality and sufficient water levels of the pools is a critical environmental issue for the Pilbara.

The Fortescue is a parallel river system with short streams ending on the alluvial plain of the Fortescue River in coalescing outwash fans. The Fortescue catchment includes the southern flank of the Chichester Range and the northern flank of the Hamersley Range. The Fortescue River valley has two major catchment systems, the upper and lower catchments which are separated by the Goodiarrie Hills (EPA, 1988).

The salinity of permanent waters in the north-west of Western Australia is low in the "fresh" category of the Water Authority of Western Australia (1989) classification of divertible surface water. The low salinity is generally attributed to long-term geochemical processes including the extensive leaching of the ancient igneous rocks of the region (Williams & Buckney, 1976). Flushing effect of heavy rainfall during the wet season is important in maintaining reduced salinities in shallow pools in the lower reaches of the system in a region with high evapo-transpiration rates and low annual rainfall.

5.6.2 The West Angelas Mine Area

An assessment of surface water hydrology was undertaken by Streamtec (1997) in order to identify the types of watercourses potentially impacted by the project, and how this may further impact on water-dependent ecosystems. The methodology of the hydrological assessment was based on the analysis of topographic maps (1:250 000) to determine stream orders, catchment areas and stream channel morphology (Streamtec, 1996).

The West Angelas area receives low rainfall resulting in highly ephemeral water courses. The majority of rainfall results from tropical cyclones between January and April. Rainfall is episodic and highly variable between years. Although the area generally receives heavy rainfall between mid-summer and early autumn, it is often insufficient to maintain flows through the watercourses.

The surface hydrology of the mining area is dominated by small first-order streams and typically small catchment areas. The only major stream of the area is Turee Creek (East) which is fifth-order sub-catchment of the Ashburton River with a catchment area of 89 km^2.

Due to the rainfall patterns, there are few well-defined drainage channels with most of the proposed mining area in the upper reaches (e.g. first to second order streams) of the Turee Creek sub-catchment. The morphology of the second-order channels indicates that substantial water would be conveyed during storm events.

5.6.3 Rail Route

Figure 5.4 shows the major catchments crossed by the rail route.

Within Karijini National Park the preferred rail easement crosses predominantly small first-order streams with the larger crossings on fifth and sixth order orders of Turee Creek with catchment areas ranging from 70.5 km^2 to 590 km^2.

There are large permanent pools in the lower reaches of the catchments crossed by the proposed rail easement (e.g. Harding, George, Fortescue and Ashburton rivers).

In the Millstream-Chichester National Park, the preferred rail easement crosses many small ephemeral first-order streams. The easement crosses the Harding River (sixth order, catchment area 133.7 km^2) and Western Creek (sixth order, catchment area 62 km^2). Between the two National Parks, the major river crossing on the preferred rail corridor is on a sixth order reach of the Fortescue River.

5.7. VEGETATION AND FLORA OVERVIEW

5.7.1 Current state of knowledge

The state of knowledge of the flora and vegetation of this botanical district is neither very detailed nor very uniform. Existing published information is confined to vegetation mapping at 1:1 000 000 scale (i.e. Beard 1975, 1980) or relatively small project specific studies, making assessment of the conservation status of the flora and vegetation difficult.

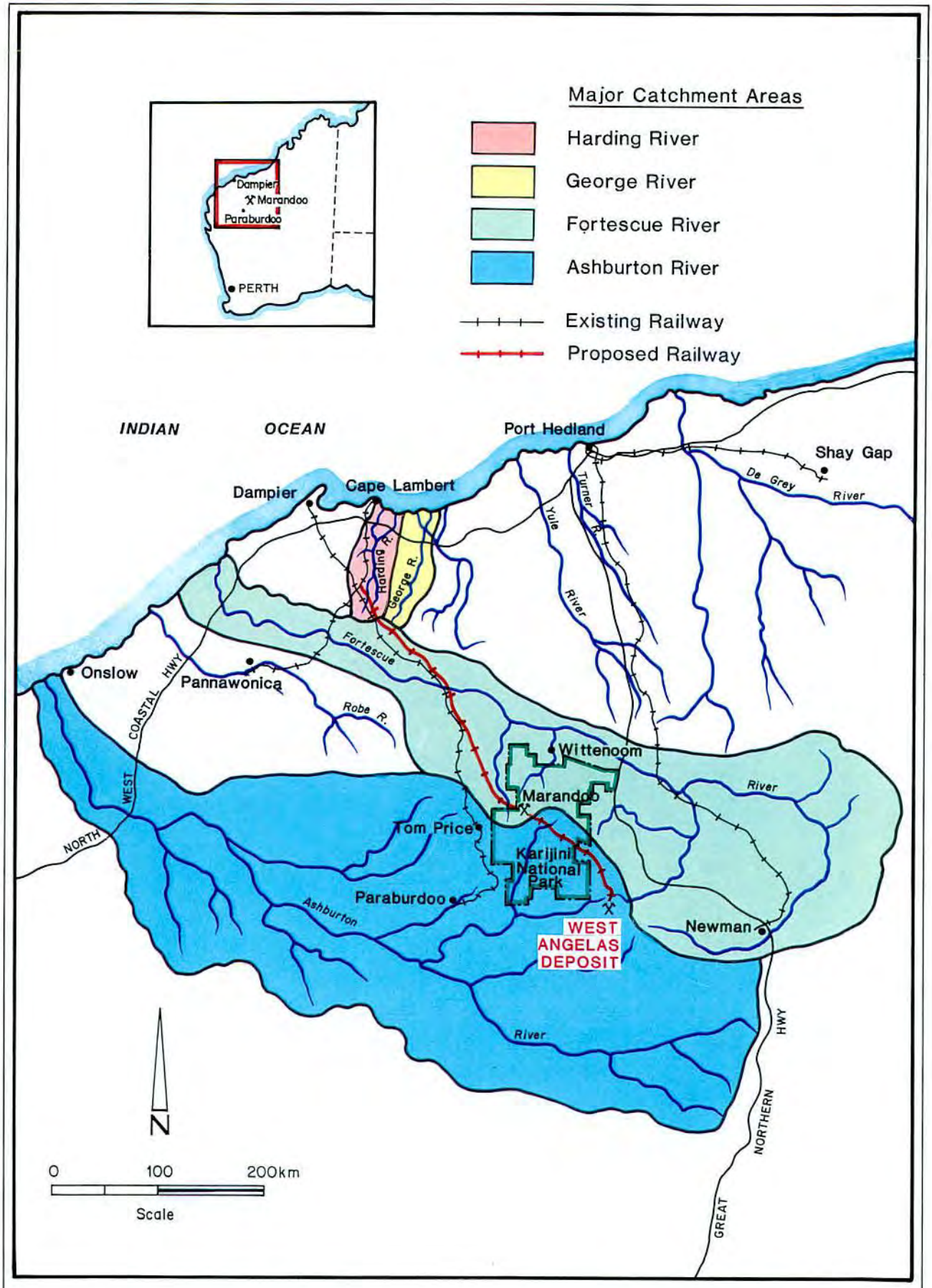
In the light of the lack of information, the known importance of parts of the project area (e.g. those parts which go through existing conservation estate) and the need to identify significant flora and vegetation associations Robe River Iron Associates commissioned a number of vegetation and flora surveys. They cover the West Angelas minesite and railway (Trudgen 1997), the access road to West Angelas, the proposed borefield (Weston and Trudgen, 1997), and the gas pipeline route (Weston, 1997). Existing detailed survey information has been utilised in considering the Marrandoo rail corridor.

The surveys add significantly to the botanical knowledge of the Pilbara both in the detailed description of vegetation and in the significant increase in knowledge of the flora of the botanical district; including the discovery of "new" species and the better definition of the population status of species that were previously little known.

5.7.2 Regional botanical context

With exception of the southern 10 km of the gas pipeline, all the areas which form part of the proposal fall in the Fortescue Botanical District as defined by Beard (1975, 1980). Beard divides the Fortescue Botanical district into eight subdivision with the West Angelas Survey Area, the various preferred railway route sections and the alternative railway route lying within the Abydos Plain, Hamersley Plateau, and Chichester Plateau subdivisions.

Beard characterises the vegetation of the ranges in his Hamersley Plateau subdivision as tree steppe of the *Eucalyptus brevifolia-Triodia wiseana* association; the valley plains are *Acacia aneura* low woodland, the basalt hills a mosaic of *Acacia aneura* low woodland and *Acacia pyrifolia - Triodia* shrub steppe, with intermediate mixtures. Minor communities include *Acacia aneura* and *Acacia xiphophylla* with spinifex, and open spinifex patches. *Eucalyptus leucophloia* replaces *Eucalyptus brevifolia* in the Hamersley Range.



Major Catchments crossed by the Preferred Rail Alignment

Figure 5.4

The southern 10 km of the gas pipeline is in the Ashburton Botanical District's Kumarina Hills physiographic unit. The predominant community of the granite plain of the Abydos Plain subdivision is, according to Beard, shrub steppe of the *Acacia pyrifolia - Triodia pungens* association containing a hummock grass cover dotted with widely spaced shrubs. Other *Triodia* species dominate on stony ground, calcrete and other soils.

Beard describes the vegetation of the Chichester Plateau as principally *Acacia pyrifolia-Triodia* steppe on the high plains' hard alkaline red soils, changing to grass savanna on the clay soils of the lower portions. *Eucalyptus brevifolia* appears on the stony ridges on the plain where the spinifex cover changes from *Triodia pungens* to *Triodia wiseana*.

5.7.3 Minesite and rail corridor survey methodology

Vegetation survey methodology

The vegetation survey of the West Angelas survey area was based on the recording of sites selected from colour aerial photography supplemented by sites chosen during the field trips guided by past experience of surveying the area. Along the rail corridors only black and white aerial photography was available. Sites were generally placed to give a higher coverage in areas of anticipated higher impact such as the two orebodies, the rail loop, the proposed accommodation facility area and the mine waste dumps. Others were chosen to provided complete coverage of the plant communities in the survey area. At each site a brief description of the habitat and the surface soil was made, the height and cover of the dominant species was recorded and as complete a list of associated species compiled as was possible within the time constraints. The size and shape of the area recorded at different sites varied depending on the habitat and the vegetation. For example, the stands of vegetation along creeklines and in gullies can be quite narrow, frequently being less than five metres across.

A number 50 m by 50 m square sites were pegged with steel fence droppers to become permanent monitoring sites.

The vegetation map and the vegetation mapping units were prepared by preparing an interpretation of the aerial photography.

Vegetation descriptions for each site were prepared using a modification of the system of Specht et. al. (1974). The modification recognises and describes understorey strata in the vegetation as well as the tallest stratum. This gives a more complete description of the vegetation at each stand.

The term association, as used in the vegetation surveys, is taken to mean a basic vegetation unit with distinctive faithful species and a group of high presence species which give it a cohesive structure. Association is not used in a structural sense where the dominants form the upper vegetation layer. An association may group any number of similar single plant communities from each of the survey sites. The further grouping of associations into "subgroups" and "supergroups" is not equivalent to the grouping of associations into alliances. Such groupings were contrived for this study in order to reflect geographic areas, geomorphology and, in many cases, shared high presence species.

The grouping of communities (the plant species from each single field site) into associations was primarily based on perennial species (those species which persist for more than seven years after germination). This approach is consistant with that recommended in several arid zone studies (i.e. Griffin 1984, Garratt 1987, Casson 1994). Incorporating short lived species into a classification of communities blurs groupings.

Dominant and associated perennial plant species were manually tabulated and cross referenced to arrive at groupings and association descriptions. Such an a-priori approach was used because the size and scope of the plant species collection and identifications precluded multivariate analysis until late in the work.

The code used to map associations is an arbitrary one. It is not based on a phytosociological interpretation such as that used by Beard (1975). However, similar codes generally imply some degree of relatedness between associations. For example, in most cases "c" at the end of a code signifies a flowline through the preceding codes association type. The codes have a general basis in geomorphology and link similar communities on similar substrates. The codes begin with a prefix which denotes the supergroup in which the association was placed. The prefixes are: 2, 5, 6, 8, 9, 10 or 11. These approximate some of the groupings recognised in the Hamersley Iron Marandoo Flora Report (Mattiske, 1992), though the categories have been adapted and expanded to cover the broader geographical and geological scope of the present work. Also, in these surveys , the prefix "3" has not been kept as a separate category. Rather, it is applied to minor flowlines within each supergroup. This was done because it became apparent that minor flowlines on sloping areas tended to have more in common with surrounding associations than with low lying flowlines. Those "3" codes which appear could just as well be prefixed with the numeral from the supergroup in which they belong.

Four field trips were made from the 8/4/97 to the 29/4/97, from the 13/5/97 to the 11/6/97, from the 30/6/97 to the 20/7/97 and from the 18/9/97 to the 28/9/97 to collect and record data for the flora and vegetation surveys.

Vegetation survey limitations

The major limitation of the vegetation surveys is the level of description and mapping of the vegetation, the use of releve or unpegged sites and difficulties associated with ranking vegetation of the landform units and the variation within them. Information on the variation within the vegetation mapping units is provided by the descriptions of individual sites. The variation in the plant communities can be determined by going directly to the site descriptions recorded for a particular mapping unit. The use of releve or unpegged sites is justified because this is a vegetation mapping, rather than a vegetation monitoring excercise. The use of releves allows the use of judgment to take into account the variation of the cover of the dominant species over a larger area.

Flora survey methodology

The flora surveys were carried out in parallel with the vegetation surveys and are largely based on the recording of species occurrence at the vegetation recording sites. However, opportunistic collections and records were also made.

Plant taxa without a scientific name are referred to either by the collection number of one collection of the taxon, a site number where a specimen of the taxon was collected, or by the combination of a descriptive word or phrase and a collection or site number. An example is one *Sida* species that could not be named and has been referred to as *Sida* sp. (site 625), as a collection was made at that site.

Four thousand seven hundred and twenty-three plant specimen collections were made during this survey.

Flora survey limitations

A variety of Mulga stands in the West Angelas Survey Area and areas adjoining it (due to the interest in this vegetation type) were searched more intensively for flora. The eastern part of the West Angelas Survey Area is relatively difficult to access and little recording was done in this area, with the very eastern section not visited at all. Overall, the intensity of the flora survey of the West Angelas Survey Area was good and this is reflected in the substantial list of species recorded.

Orebodies A and B were sampled twice (in 1997 and in 1995 to take advantage of the very good winter rains experienced during that year). When the lists of plants collected on the two orebodies were compared, it was found over 50 taxa were recorded in the 1995 work were not recorded in 1997. This illustrates the difficulty of collecting complete (or even near complete) inventories of plant species for any significant sized area and suggests that the lists for these two areas, while

improving current knowledge substantially, would still be incomplete.

Due to the linear nature of the railway, the vegetation recording sites were generally targeted at the centre of the two kilometre strip mapped, approximately where the rail line will be built. However, sites were also recorded away from the centre to sample different vegetation types such as creeklines with permanent or semipermanent wet areas that would be susceptible to weed invasion. The sites were also chosen to sample a range of the vegetation present.

Given these limitations, the intensity of the flora searches in the various rail sections is very good and this is reflected in the extensive flora lists recorded. The effectiveness of the flora searches was increased by the generally good flowering season over most of the rail sections at the time they were surveyed. The only exception to this were the Four Corners Bore and Eight Mile Well rail sections which did not receive follow-up rains. However, many annual species were still identifiable and this area is better known botanically than the other areas surveyed, except possibly Coondewanna Flats.

It is considered that the flora recorded for the railway alignments is probably between 75percent and 85percent of the flora that occurs in them, with the two sections on Hamersley Station being near the lower end of this range.

Lichens, mosses, liverworts and fungi were not systematically collected or recorded because they are difficult groups to work with and have relatively small contribution to the biomass. This is common practice in environmental impact assessment survey work.

5.7.4 Borefield and gas pipeline survey methodology

The borefield vegetation and flora survey undertaken by Weston and Trudgen and Casson (1998) and the gas pipeline vegetation and flora survey by Weston (1997) mapped vegetation types using a methodology based on Specht et. al. (1974) which "recognises and describes the understorey strata in vegetation as well as the tallest stratum". This methodology is consistent with other surveys in the area. Sites visited in the field were determined by using black and white aerial photographs, assessments made during field work, accessibility and the location of previous vegetation survey sites. Unfortunately, peak flowering period was past when the survey was undertaken. The vegetation maps are representative, rather than definitive.

Definition of the vegetation types was tied to landform systems using similar groupings to Mattiske & Associates (1992).

5.7.5 Assessment of conservation values

As previously noted the lack of detailed knowledge for the project area can make assessment of the conservation status of the flora and vegetation more difficult than in areas where the existing knowledge base is better.

Description of the vegetation of a survey area allows comparison of the vegetation found there with the more general regional descriptions available. This allows judgements to be made on whether or not the vegetation in the survey area is within the scope of the variation generally found within the regional unit in which it lies. It follows that these judgments are based on the field work and report preparation and this has to be adequate if the judgments are to be soundly based and seen to be adequate if the assessments are to be accepted.

The assessment of conservation values is discussed in section 5.9 of the ERMP.

5.8. TERRESTIAL VEGETATION

This section considers vegetation type (i.e. associations or communities of plants).

5.8.1 West Angelas Mine Area

West Angelas lies in the Fortescue Botanical District of the Eremean Province, although it is close to the boundary between the Ashburton and Fortescue Botanical Districts. This location is significant in that the boundary divides the *Acacia* dominated communities of the Gascoyne region from the *Triodia* dominated communities of the Pilbara (Beard, 1975).

In 1978 a biological assessment survey was conducted in the West Angelas area by Integrated Environmental Services. Based on the composition of flora species identified in the area, the survey delineated the following seven vegetation units:

(i) *Acacia pyrifolia / Triodia pungens;*
(ii) *A. pyrifolia / T. longiceps;*
(iii) *A. victoriae / T. longiceps;*
(iv) *A. pyrifolia / Ptilotus rotundifolius;*
(v) *A. aneura / T. pungens;*
(vi) *T. basedowii / P. rotundifolius;* and
(vii) *T. basedowii.*

None of these plant communities were found to be restricted to areas of enriched Marra Mamba Formation at West Angelas, each being duplicated on the Brockman Formation (Integrated Environmental Services, 1978).

A further botanical survey of the West Angelas Survey Area an area within a rectangle approximately 12 km wide by 37 km long adjacent to the south-east part of the Karajini National Park and which includes Orebodies A and B was carried out in 1997 (Trudgen, 1997). Vegetation maps from this survey appear in Appendix C.

Regional assessment and conservation values based on Beard (1975)

The West Angelas Survey Area lies entirely within Beard's (1975) Hamersley Plateau physiographic unit. In this unit, the vegetation falls within three categories based upon the topography and soil characteristics. They are:

(i) The ranges. On jaspilite and dolomite, where the soils are often stony and shallow, the vegetation is characteristically tree steppe of the *Eucalyptus brevifolia-Triodia wiseana* association. Associated flora may include; *Eucalyptus gamophylla, Cassia desolata, Dodonaea viscosa, Acacia maitlandii, Petalostyles labicheoides* and*Triumfetta chaetocarpa* as well as a rich flora of herbaceous species. On the more elevated areas of this unit, the mallees, *Eucalyptus kingsmillii* and *Eucalyptus gamophylla* are common. On the steep, rocky sides of the gullies, the shrub species *Astrotriche hamptonii* occurs, while the base supports a riverine woodland of *Eucalyptus camaldulensis, Eucalyptus dichromophloia , Eucalyptus microtheca, Acacia pruinocarpa, Melaleuca argentea* and *Acacia tumida.* Over half the West Angelas Survey Area has this subunit of the Hamersley Plateau physiographic unit.

(ii) Valley plains. The valley plains support the mulga formation (*Acacia aneura* low woodland) with areas of grass plains, often on cracking clay soils. These have *Astrebla pectinata* together with *Aristida latifolia, Chrysopogon fallax* and *Eragrostis setifolia.* Approximately one third of the West Angelas Survey Area occurs on the valley plains.

(iii) Basalt hills. Beard (1975) mapped this area as 'mulga and spinifex'. It forms a mosaic of *Acacia aneura* low woodland and *Acacia pyrifolia-Triodia* shrub steppe. Areas with basalt hill formations occur in the centre of the West Angelas Survey Area and occupy a small, but significant, part of it.

At a very broad level, the vegetation recorded in the West Angelas Survey Area is within the range of

vegetation described by Beard (1975) for the Hamersley Plateau physiographic unit. The West Angelas area undoubtedly has conservation value at this broad level of analysis. The size of the West Angelas Survey Area and the high diversity of vegetation associations within it mean that this conservation value for vegetation is very high.

This assessment is reinforced by the very good condition of the vegetation, particularly the Mulga stands, in the West Angelas Survey Area, due to the fact that it has had very little grazing as a result of the lack of water for stock. The presence of a high diversity of Mulga vegetation, many stands of which have the geographically restricted *Acacia* aff. *catenulata* co-dominant or dominant, increases substantially the overall value of the vegetation of the West Angelas Survey Area. This is due to the fact that in many of the other parts of the Fortescue Botanical District where they occur, Mulga stands have been degraded by a combination of grazing and frequent burning. These values extend outside the West Angelas Survey Area, particularly to the north, east and south.

Survey results and vegetation with particular conservation value

Sixty-two vegetation units are described for the West Angelas Survey Area in this report. These are from five supergroups: the prefix 2 supergroup (major and minor floodlines), prefix 5 (vegetation of iron bearing formations), prefix 6 (vegetation of valleys, plains, low foothills and escarpments), prefix 8 (vegetation of the Jeerinah Formation volcanics and derivatives) and prefix 11 (vegetation of the Wittenoom Formation). Within these supergroups, 17 mosaic units were recognised. The supergroups and associations are described in Trudgen (1997).

Several of the sixty-two vegetation associations described for the West Angelas Survey Area in this report were not present on the other survey areas. There were two on the orebodies, several in the *Acacia aneura* vegetation in the valleys, and two on the Jeerinah Formation.

The three associations which were unusual amongst those sampled on the orebodies in this study are associations 6adb215 on Deposit A and association 5kdm3g on Deposit B. Information relating to Deposit A is discussed first.

Associations 6adb215 and 6adb234 were recorded on Deposit A but were not recorded in the other areas surveyed for this ERMP, and therefore have moderate conservation value. These are variants of similar associations on other landforms in the other study areas. For example, association 6adb215 is dominated by *Aristida contorta* and also has *Eragrostis pergracilis*. Both of these species are common to many associations in the region. This association was confined to a small clay patch at the Western extremity of Deposit A. Association 6adb234 is dominated by Mulga and occurs only on a low rise on the south side of deposit A. It shares several key species with 6adb231. The species which distinguish association 6adb234 from 6adb231 are *Corymbia hamersleyana*, *Eremophila fraseri* ssp. *fraseri* and *Sarcostemma australe* with *Cassia "glaucifolia"*, *Eragrostis eriopoda*, *Ptilotus rotundifolius*, *Eremophila phyllopoda* ssp. *obliqua*, *Eremophila latrobei* spp. *glabra*, and *Hakea suberea* being less important. Association 6adb231 is present in the West Angelas access road study area and in the Coondewanna West rail section.

The vegetation of some areas adjoining Deposit A within the West Angelas survey area also need to be mentioned here, as they may be affected by impacts associated with the mining of the Deposit. These are: the mulga stand on the large alluvial fan next to the south side of the west end of Deposit A, areas of cracking clay adjacent to the north side of the west end of Deposit A and areas of Mulga on the Jeerinah Formation north of Deposit A.

The mulga stand on the large alluvial fan next to the south side of the west end of Deposit A is a very good example of this vegetation and has significant conservation value. However, this mulga type also occurs on similar alluvial fans to the east of Deposit A and on the south side of the Brockman Formation ridge, south of Deposit A. Narrower strips of similar Mulga also occur along the colluvial fans of the Brockman Formation ridge, south of Deposit A and along both sides of the ridge system, west of West Angela Hill.

The areas of cracking clay, adjacent to the north side of the west end of Deposit A, are situated along the floodplain of the same flowlines which drain the Deposit. They have moderate conservation value for their vegetation, but also have significant flora value (see section six). These cracking clay areas only represent a minor proportion of the West Angelas area. They are significant in a regional sense partly because cracking clays are a relatively small part of the region, and partly because they are in a very good condition because they have not suffered the impact of grazing for pastoral production. The flora developed on the cracking clay areas is dependent upon the long-term pattern of flow and sediment deposition on them and may be subject to indirect as well as direct impacts.

The areas of Mulga on the Jeerinah Formation north of Deposit A are part of a number of fairly small stands on this formation in the West Angelas area. They differ floristically from those on the other geological types and seem to have quite limited extent.

Association 5kdm3g was recorded on Deposit B but was not recorded on the other areas surveyed and therefore has moderate conservation value. It has *Eucalyptus gamophylla* over *Acacia hamersleyensis* and *Triodia pungens* and is a variant of similar associations on other landforms in the other study areas. It is similar to association 5kdm3, of which it is a derivative, and to 5edacl, of which it is an analogue. These associations are fairly common and association 5kdm3 occurs in the Coondewanna West rail section and the West Angelas access road survey area. Association 5edacl occurs in the Mt. Robinson and Coondewanna West Rail Options.

The vegetation of some areas adjoining Deposit B within the West Angelas survey area also need to be mentioned here as they will be, or may be affected by impacts associated with the mining of the Deposit. This vegetation is: the vegetation along the cliffs on the south side of the ridge next to Deposit B and the mulga stands near the west end of Deposit B.

The vegetation along the cliffs next to the ridge on the south side of Deposit B contains populations of *Eremophila platycalyx* ssp. *pardalota*. This is a priority species, but is poorly collected rather than rare.

The Mulga stands near the west end of Deposit B are quite varied and are different to those on the colluvial and alluvial fans.

Only one area of association 6adb25 was encountered during the survey, suggesting that it has significant conservation value. It is located in the middle of the northern side of the survey area, at a point where the Mt. Robinson and Coondewanna West options join the West Angelas Survey Area, so that the single patch is common to all three. Association 6adb25 has *Acacia aneura* var. (green, flat; M.E.T. 15, 946) over *Rhagodia* sp. Hamersley over *Maireana* spp. with *Plectrachne melvillei* on gradual valley slopes. However, *Acacia aneura* var. (green, flat; M.E.T. 15, 946) was recorded in other vegetation types and was present in associations in the West Angelas access road survey area and in association 6adb24, which was present at three sites in the Coondewanna West rail section.

Association 6adb233 was confined to the valley at the north of the West Angelas Survey Area. It has less conservation significance than 6adb25 because the dominant species are more common. The dominants were *Acacia* aff. *aneura* (narrow, green; M.E.T. 15, 850), *Acacia paraneura*, and *Acacia aneura* var. ? *aneura* over *Eremophila lanceolata.*

Moderate conservation significance is suggested as appropriate for two restricted *Acacia aneura* associations. The first is association 6adb214, which occurs on the western edge of Deposit B. It was of limited occurrence (three sites), but it occurred in both the West Angelas Survey Area and on Hamersley Station. The association is located downstream from Deposit B and is situated on either bank of Turee Creek. Association 6adb214 has *Acacia* aff. *aneura* (narrow, green; M.E.T. 15,850), *Acacia* aff. *catenulata* and *Acacia aneura* var. *longicarpa* over *Eremophila forrestii ssp. forrestii* and *Rhagodia eremaea* over *Chrysopogon fallax.* The second is association 6adb213, which has the locally common dominants *Acacia* aff. *aneura* (scythe-shaped, M.E.T. 15,743), *Acacia pruinocarpa* and *Acacia* aff. *aneura* (grey, bushy form; M.E.T. 15,732) over *Eremophila forrrestii* over *Triodia pungens.*

Two associations from the Jeerinah Formation also seem to have conservation significance. Firstly,

association 8dd was recorded from only one site and was the only site in the whole West Angelas Survey Area which had *Astrebla squarrosa* (growing in association with *Sida fibulifera*). Secondly, association 8cja was recorded from only one site, which was the only site which had *Chenopodium auricomum* over *Eragrostis setifolia.*

Association 5edba is of less conservation significance for individual stands, but is noteworthy because it is the main association to have *Acacia* aff. *catenulata* dominant in the West Angelas Survey Area. Several other associations in the West Angelas Survey Area have *Acacia aff. catenulata* subdominant or co-dominant. Within the West Angelas Survey Area association, 5edba mostly developed on minor flowlines draining the mid to lower slopes of Brockman Iron Formations.

None of the vegetation associations described for the Deposit A study area are so unusual that they are of high conservation significance.

5.8.2 Borefield vegetation

The vegetation types mapped by Weston and Trudgen and Casson (1998) are described by dominant vegetation below. Associated species for each vegetation type appear in Weston and Trudgen (1997).

Vegetation Type 2: Major Flow Lines and Creeks

Vegetation Unit 2a: *Acacia aneura* var. *longicarpa* , *Acacia aneura* sens. lat. high shrubland to low woodland over *Triodia pungens* open hummock grassland over *Enneapogon caerulescens* var. *occidentalis* mixed annual tussock grassland and *Ptilotus helipteroides* var. herbland.

Vegetation Unit 2c: *Acacia citrinoviridis* low woodland over *Ptilotus obovatus* low shrubland over open annual tussock grassland

Vegetation Unit 2d: *Eucalyptus victrix* open woodland over *Acacia citrinoviridis* low open woodland over *Acacia pyrifolia* open shrubland over open tussock grassland

Vegetation Type 3: Minor Creeks

Vegetation Unit 3a: *Corymbia ?hamersleyana* scattered low trees and *Acacia* spp. shrublands over *Triodia* spp. hummock grassland.

Vegetation Unit 4a: *Acacia aneura* var. *longicarpa* low open woodland and high open shrubland over *Aristida contorta* annual tussock grassland

Vegetation Unit 4ag: *Acacia* aff. *aneura* (scythe shaped; MET 15,743) low open forest over *Eremophila forrestii* subsp. *forrestii* MS open shrubland over *Triodia pungens* hummock grassland. The *Acacia* aff. *aneura* (scythe shaped; MET 15,743) occurs in groves.

Vegetation Unit 4c: *Acacia aneura* var. *longicarpa* very scattered shrubs over *Salsola kali* low shrubland over *Ptilotus aervoides*, *Lepidium phlebopetalum*, *Tragus australianus* open annual herbland/grassland.

Vegetation Type 5: Mountain Ridges, Slopes and Colluvial Fans

Vegetation Unit 5a: *Eucalyptus leucophloia* very scattered low trees over *Acacia* aff. *aneura* (narrow, green: MET 15,850) scattered tall shrubs over *Cassia glutinosa* open shrubland over *Eremophila compacta*, *Ptilotus rotundifolius* low shrubland over *Triodia pungens*, *Triodia* aff. *basedowii*, *Triodia wiseana* open hummock grassland to hummock grasslands

Vegetation Unit 5b: Very scattered tall shrubs of *Acacia aneura* sens. lat. over *Eremophila forrestii* subsp. *forrestii* MS low open shrublands over *Triodia pungens* hummock grassland.

Vegetation Unit 5h: *Acacia wanyu* shrubland over *Cassia 'stricta'*, *Maireana georgei*, *Sclerolaena*

eriacantha low open heath over *Aristida contorta*, *Eriachne pulchella* subsp. *pulchella* very open annual tussock grassland and *Triodia pungens* scattered hummock grasses.

Vegetation Type 6: Low Hills

Vegetation Unit 6a: *Acacia* aff.*aneura* (narrow, green: MET 15,850)? high shrubland over *Cassia 'stricta'* low shrubland over *Triodia pungens* hummock grassland and *Aristida contorta*, *Eriachne pulchella* subsp. *pulchella* open annual tussock grassland.

No vegetation types were located during the field survey that were outside the range of the vegetation types expected.

The vegetation of the proposed borefield is generally in very good condition, with only a small number of tracks and limited evidence of weed invasion or heavy grazing. A recent fire has burnt about 30percent of the study area, but a single fire is not likely to significantly reduce conservation values. Repeated burning can reduce vegetation conservation values. The good condition of the vegetation is not unusual in the context of the region.

The value for conservation of each of the five vegetation types described for the study area was assessed in relation to the Land Systems and units of Payne et al (1988). All of the vegetation types rated as either low to moderate or low value for conservation.

5.8.3 Gas pipeline to West Angelas

The gas pipeline vegetation and flora survey undertaken by Weston (1997) used the same methodology, same broad landforms and had the same limitations as the survey by Weston and Trudgen and Casson (1998) for the borefield. Whilst the same landforms were used as a framework for determining vegetation types the subdivisions within each broad landform are different (e.g. Vegetation type 2 is Major Flow Lines and Creeks in both reports, but there is no similarity between the vegetation types identified as 2a in the reports).

The vegetation of the proposed pipeline corridor is generally in very good condition, with only limited evidence of weed invasion, recent fire, heavy grazing or other disturbance. There are livestock and signs of grazing on the plains in the southern section of the corridor. The effects of grazing in this section range from minor to moderately severe. Relatively small areas of slopes, hills and ridges in the central part of the corridor have been burnt in the last two to three years. The burns were probably from fires which burnt much larger areas nearby outside the corridor.

Human disturbance has largely been restricted to the cutting of exploration lines in the Vegetation Type 1 mulga woodlands and adjoining vegetation in the northern section of the corridor and the grading of a few rough tracks across the central and northern sections. Some of the exploration lines have been ripped and rehabilitated or are now overgrown by vegetation.

Dominant vegetation and associated species for each vegetation type identified at the borefield appear in Weston (1997).

Weston (1997) did not note any particular vegetation type as having conservation significance, but did comment on the conservation value of flora within a vegetation type.

5.8.4 Railway - Coondawanna West

Regional assessment and conservation values based on Beard (1975)

The Coondewanna West rail section lies entirely within the Hamersley Plateau physiographic unit of Beard (1975). Beard describes the terrain of this unit as consisting of valley plains and dissected stony hills. The Coondewanna West rail section has a mixture of these. The valley plains have Beard's mulga formation (*Acacia aneura* low woodland), while the hills have his *Eucalyptus brevifolia-Triodia wiseana* association. The Coondewanna West rail section is largely in the mulga

formations of the valley plains. At one point, it runs close to the eastern end of a large claypan. This claypan has *Eucalyptus victrix* and Mulga over *Eriachne flaccida* grassland. The northern part of the Coondewanna West rail section passes through a mixture of Beard's *Eucalyptus brevifolia-Triodia wiseana* association and *Acacia aneura* low woodland.

At a very broad level, most of the vegetation recorded in the Coondewanna West rail section is within the range of vegetation described by Beard (1975) for his Hamersley Plateau physiographic association.

The exception to this is the claypan or seasonal lake on the Coondewanna Flats west of Mt Robinson. The Coondewanna West rail section includes one small part of it, and the actual rail alignment marked on the maps used in the survey was a short distance outside the claypan.

The most noticeable features of the vegetation of the Coondewanna West rail section at a broad level are the very large variation in the Mulga stands and the presence of areas of grasslands (some with scattered Mulga) in the lower parts of the broad flow zones between the ridges in this rail section. Collectively, these have very high conservation value for vegetation, particularly as the vegetation is generally in excellent condition. This grouping of Mulga and broad flow areas extends south and east from the Coondewanna West rail section to at least the Angelo River area. There is large variation in the composition of the Mulga stratum and in the associated species in the Mulga dominated areas. This variation is unusual in both the diversity of the variation and the many individual stands present and the (at times) rapid changes between them. The grasslands occur on the clayey bases of the lower parts of the broad flow zones between the ridges in this survey area, some of which approach the clay pan environment in the pale clay soil and water retention after rain. These areas are not mapped by Beard (1975), as the individual occurrences are too small at the scale of his mapping. They would be placed in Beard's unit "xGc", but the stands are quite different associations when compared with examples of this unit sampled in other areas surveyed for this report.

The areas of Beard's *Eucalyptus brevifolia - Triodia wiseana* association that occur in the Coondewanna West rail section are reasonably typical of this association, but were mostly only sampled on lower slopes.

Survey results and vegetation with particular conservation value

Forty-four vegetation associations were described for the Coondewanna West rail section during this survey. These came from two supergroups: the prefix 5 supergroup (vegetation of iron-bearing formations) and prefix 6 (vegetation of valleys, plains, low foothills and escarpments). The supergroups and associations are described in Trudgen (1997).

Of the forty-four associations recorded for the Coondewanna West rail section, thirteen were dominated by forms of *Acacia aneura*. This was more than in the West Angelas Survey Area and several more than on the Mt. Robinson route.

Of the forty-four associations, twenty-four were only recorded at one locality during this survey, four were recorded at two localities in the Coondewanna West rail section and one was recorded at three localities in the Coondewanna West Rail section. While most of these associations are similar to associations in other areas, the Coondewanna West rail section has high conservation value for a number of associations that were restricted to it in this survey. An example of this is association 6adb25. This has *Acacia aneura* var. (green, flat; M.E.T. 15, 946) over *Rhagodia* sp. Hamersley over *Maireana* spp. with *Plectrachne melvillei*, on gradual valley slopes. Only one area of this association (in a joint section of this rail section, the Mt Robinson rail section and the West Angelas Survey Area) was encountered during this work. It is likely that some of the associations restricted to the Coondewanna West rail section also occur to the south and east of the West Angelas Survey Area, as there is potential habitat for them in those areas. However, they are likely to be scarce on a regional basis.

5.8.5 Rail corridor - Marandoo Corridor

Mattiske & Associates (1992) identified 37 plant community types within the Marandoo Project area which they distinguished on the basis of their structure and floristics, their representation on an aerial basis and their sensitivity to factors controlling their distribution. These communities are dependent upon the underlying geology, landforms, soils and hydrological conditions. To assist in interpretation these vegetation units were linked with underlying landform and soil groupings.

In Broad Drainage Areas and Basins within the project area four communities were recognised. These were *Acacia aneura* woodland, open herbfield of mixed Poaceae species and hummock grasslands of *Pletrachne melvillei* and *Pletrachne melvillei /Triodia pungens*.

In the Major flow-lines and creeks five different *Acacia* and Eucalypt woodlands were described. The dominant species included the species *Acacia aneura, A. pruinocarpa* and *A. citrinoviridis* and *Eucalyptus patellaris, E. camaldulensis* and *E. coolabah*. The understorey in all five flow-line communities was diverse.

The minor creeks of the project area were dominated by low shrublands of mixed *Acacia* species or a low woodland of mixed mallee species (*Eucalyptus trivalvis - E. striaticalyx* and *E. socialis)*.

Seven distinct communities were recognised on the flats of the Marandoo Project Area. This included the three *Acacia* dominated communities of *Acacia aneura - Acacia pruinocarpa* woodland, *Acacia xiphophylla* low woodland and *Acacia farnesiana - Acacia victoriae* low shrubland as well as the open herbfield of mixed Poaceae spp. with occasional *Acacia aneura*. Three hummock grassland communities were also recognised with dominant species being *Triodia wiseana / Triodia pungens, Triodia wiseana / Triodia basedowii / Triodia angusta* and *Triodia angusta / Triodia longiceps*.

Not all of the nine communities recognised from the ridges and erosional spurs of the project area were present within the rail corridor area. Those present were Hummock grassland communities dominated by *Triodia wiseana, Triodia basedowii, Triodia brizoides* and/or *Triodia pungens* with occasional emergents. Emergent species included *Eucalyptus leucophloia, Eucalyptus gamophylla* and mixed *Acacia* species.

On the low foothills and escarpments six communities were recognised by Mattiske & Associates (1992). It was dominated by low woodlands of mixed *Acacia* (largely *aneura*) and mallee (*Eucalyptus trivalvis* and *E. socialis*) species with an understorey of mixed *Trioidia* spp. On the upper slopes and ridges of some areas in the south-east rail corridor mixed *Triodia* spp. dominated to form a hummock grassland.

Four communities were recognised from the Volcanics landform in the north-western rail corridor. Two of these communities were low woodlands dominated by *Acacia aneura* distinguished by their location either on the low hills or the breakaways of this area. Hummock grasslands of *Triodia wiseana* and low shrubland of mixed *Acacia* spp were also recognised in the Volcanic areas.

Most of the communities identified in the Marandoo project area extend into Karijini National Park or into adjacent Crown land and a number have been significantly affected in the past by factors such as grazing and fire. However, a number of plant communities were identified as being of local or regional conservation significance due to their lack of representation in conservation areas or their sensitivity to change. Many of these communities were recorded in the proposed rail corridor by Mattiske & Associates (1992).

Some of the communities on the volcanics in the proposed north-western section of the rail corridor were found to have a large number of rare or restricted flora species. The low shrubland of mixed *Acacia* species on the backslopes and the low woodland of *Acacia aneura* on small breakaways in these areas were further noted as being relatively restricted in the Pilbara region.

Low Mallee woodlands and hummock grass on the calcrete soils of the Oakover formation in the north-western section of the South east transport corridor are poorly represented in conservation

areas (Mattiske & Associates, 1992). Communities containing populations of *Eucalyptus* aff. *coolabah*, *Crotalaria benthamiana* and *Pimelea holroydii* were found in both corridors and are also considered significant as these species are poorly represented in conservation areas.

Gullies and water-courses were considered significant due to their high species richness (Mattiske & Associates, 1992). The *Eucalypt* and *Acacia* woodlands on the major flow lines and creeks were noted as particularly species rich. *Acacia* and *Eucalypt* woodlands, grasslands, low acacia shrubland and low mallee of the drainage areas, drainage lines and minor creeks were also reported to be particularly sensitive to disturbance.

A number of species of conservation significance were recorded from the communities of low *Acacia* shrubland and open grassland on cracking clay and in low woodlands of Snakewood (*Acacia xiphophylla*). These communities are considered sensitive to disturbance, particularly from grazing.

5.8.6 Rail corridor - Hamersley Station Flats: Four Corners Bore route

Regional assessment and conservation values based on Beard (1975)

The Four Corners Bore route is entirely within the Hamersley Plateau physiographic unit of Beard (1975), who describes the plateau landscape as one of rounded hills and ranges. Where alluvial plains occur, the soils are mostly deep loams with patches of deep cracking clay. Beard describes the vegetation of the ranges as characteristically tree steppe of the *Eucalyptus brevifolia-Triodia wiseana* association which, he says, has a rich flora of small shrubs and herbs, but few large shrubs. On the valley plains, *Acacia aneura* (mulga) low woodlands predominate. Where the plains are wide and flat, they may develop into open grasslands.

Within the Hamersley Plateau physiographic unit, the Four Corners Bore route crosses four of Beard's (1975) plant communities. The southern end is in mulga low woodland, which forms a narrow strip between an area of grassland to the west and a tree steppe to the east. The route passes through a mosaic of *Eucalyptus brevifolia-Triodia basedowii* and mulga low woodland, before crossing into a grassland association on the Hamersley Homestead Plain. At the northern edge of the plain, the rail section crosses another area where mulga woodland predominates, before moving into an area with a mosaic of *Eucalyptus brevifolia*, *Triodia basedowii* and *Eucalyptus dichromophloia-Triodia pungens* associations in a hilly part of the ranges.

At a very broad level, most of the vegetation recorded in the Four Corners Bore route is fairly common in the Wittenoom to Tom Price area of the Hamersley Range. The one exception to this is that part of the Four Corners Bore rail section which crosses a narrow part of the "Hamersley Homestead Plain", which Beard maps as his vegetation unit "xGc" or "short grassland". In his discussion of the valley plains for the Hamersley Plateau physiographic unit, Beard says:

On grass plains with red cracking clay soils, Astrebla pectinata appears to be dominant together with Aristida latifolia.... On one area sampled Themeda australis was dominant, with Calocephalus aff. knappii and Ptilotus carinatus. (Beard 1975, page 74).

The "Hamersley Homestead Plain" is a mosaic of soils with much red cracking clay. Most areas of red cracking clay in the Hamersley Plateau physiographic unit that have perennial grassland have *Astrebla pectinata*, or mixtures of this species with other perennial grasses, especially *Eriachne benthamii*. There are some areas of such vegetation on the "Hamersley Homestead Plain", but it mostly has tall grasslands of *Themeda* sp. Hamersley Station (M.E. Trudgen 11,431). This seems to be the area that Beard mentions as having *Themeda australis* as dominant. This conclusion is suggested by a specimen of Beard's that is *Themeda* sp. Hamersley Station (M.E. Trudgen 11,431) from the Hamersley Homestead Plain, which was originally determined as *Themeda australis*.

The *Themeda* sp. Hamersley Station (M.E. Trudgen 11,431) tall grasslands on the Hamersley Homestead Plain are unique to that area and to a claypan nearby, adjacent to the road to Mt Bruce. Although this species is moderately widespread in the Fortescue Botanical District it only occurs as scattered plants or very small stands at the other known locations. At the northern edge of the Hamersley Homestead Plain, there are also some open woodland and shrubland areas on low rises

where calcrete is close to the surface. This vegetation seems to be unusual. This plain is known to have populations of several priority flora species and other species of conservation interest (see section 5.9).

The extremely broad nature of Beard's study is shown by the fact that 21 vegetation associations have been described by Trudgen and Casson (1998) for the Four Corners Bore route.

Survey results and vegetation with particular conservation value

As stated above 21 vegetation associations were described for the Four Corners Bore rail section during the survey undertaken for the ERMP. These came from three supergroups: the prefix 2 supergroup (major and minor floodlines), prefix 5 (vegetation of iron bearing formations) and prefix 6 (vegetation of valleys, plains, low foothills and escarpments). Trudgen and Casson (1998) describes the vegetation association in detail and tabulates their frequency of occurence

Association 6adb4, which has *Themeda* sp. Hamersley Station (MET 11431) dominant, is the most significant association in the Four Corners Bore rail section. This association is an unusual occurrence at the regional level. It is more usual for *Themeda* sp. Hamersley Station (MET 11431) to be a minor component of associations, such as in 6adb1 and 6adb2. The only other known association with a *Themeda* sp. Hamersley Station (MET 11431) is located a short distance outside the Four Corners bore rail section in a clay pan adjacent to the road to Mt Bruce. This is association 6/2epa which otherwise had similarities with those on Coondewanna Flats in the Mt Robinson route.

Association 6adb4 was observed in the north east part of the route, just to the south of the ranges proper, but outside of the Four Corners Bore route.

Several other associations were restricted to the Four Corners Bore Rail option. These are association 2bc, 5ik, 5ke, 5kec, 5kee and 6adb5. Association 2bc is a variant of association 2b, which was recorded in the Hamersley Parallel rail section. Association 5ik is a variant of 5ic which was recorded in the Mt. Leal and George River rail sections, and is also similar to associations on iron formations to the south, such as association 5kdm2. Associations 5ke, 5kec, 5kee are from a series of associations that have *Corymbia hamersleyana* or *Eucalyptus leucophloia* over *Triodia wiseana* or *Triodia pungens*, None of the key species of these associations is uncommon and these associations were recorded at more than one site. Association 6adb5 occurs on small pockets of clay-loam duplex soils on gentle slopes on plains and has *Acacia xiphophylla* over *Eragrostis xerophila*, *Aristida latifolia* grassland. It follows that these associations do not have high conservation significance from the point of view of the component species in the associations; however, at the level of association structure they are distinct within the areas studied.

A number of associations present in the Four Corners Bore rail section were only recorded in this rail section and/or the Eight Mile Well rail section, which is an alternative route for part of Four Corners Bore. These are associations 5kf, 5kfc, 5kfe, 5kfm, 5kfn, 6adb1, 6adb2, 6adb3, 6add, 2eab and 2ecp. The number of associations in this group suggests that the valley plain environment and adjoining low rises have vegetation that is different from the higher areas of the Hamersley Range. The number of this group of associations suggest that the valley plain environment and adjoining low rises have vegetation that is significantly different from the higher areas of the Hamersley Range and thus have conservation significance.

The prefix five supergroup associations 5kf, 5kfc, 5kfe, 5kfm, and 5kfn have *Corymbia hamersleyana* over *Triodia wiseana* or *Plectrachne melvillei* hummock grasslands. Associations 5kfm and 5kfn were recorded at only one site each and appear to be restricted in distribution. However, the key species are *Plectrachne melvillei* and the absence of *Eucalyptus leucophloia* . The differences between these associations is not of great conservation significance. The prefix six supergroup associations 6adb1, 6adb2, 6adb3 have *Acacia aneura* var. *longicarpa*, *Eucalyptus xerothermica* and *Acacia pruinocarpa* over *Aristida latifolia* and *Chrysopogon fallax*. This group of associations covers several kilometres of the rail section and forms interrelated mosaics, with significant overlap in species. Association 6add has *Acacia xiphophylla* over *Triodia wiseana* and has occasional individuals of *Acacia synchronicia*, *Acacia bivenosa* and *Eucalyptus trivalvis*. This association is part of a group of associations (e.g. 5j, 6adb and 6adc) with *Acacia xiphophylla* dominant which occur in small areas, but are widespread as a group. Association 2eab is a variant of association 2ea which is present in the Mt. Leal and Coondewanna West rail sections. Association 2ecp has an upper stratum of *Acacia citrinoviridis*, *Eucalyptus victrix* and *Acacia aneura* var.

longicarpa. It is restricted to creek banks with deep loamy soils, but is likely to be widespread.

One association, 2ecla, was present in the Four Corners Bore rail section and also in the Hamersley Parallel rail section. It is close to association 2eclb and both are close to association 2ecl, but have *Eucalyptus camaldulensis* rather than *Eucalyptus victrix*. These associations are part of a group of related associations that occur along creeks and rivers over a wide area and, while different from other associations in this group recorded during the survey, association 2ecla is not considered to be of high conservation significance.

5.8.7 Railway- Mt Leal

Regional assessment and conservation values based on Beard (1975)

The beginning of the Mt Leal rail section is on gentle, south facing slopes of the north side of the Fortescue Valley in an area mapped by Beard (1975) as tree steppe. Beard has treated this area as part of the Chichester Plateau in his discussion, but this is a generalisation necessary at the scale of his study. Part of this area of tree steppe is in the valley and part on the slopes leading to the plateau (the transition is gradual). Approximately halfway along the rail section, the route enters the vegetation of the Chichester Plateau. On the Plateau, the Mt Leal rail section passes through two of Beard's (1975) vegetation units. They are *Acacia pyrifolia-Triodia* shrub steppe on the alkaline red basalt soils and a "short grassland", which is annual grasslands on the cracking clay soils. The first of these units is the more widespread. The second is very variable, being a mosaic of plant communities including open herbland/grassland of Asteraceae, Poaceae and *Ptilotus* species, *Acacia pyrifolia* over *Triodia wiseana* hummock grassland and *Eriachne benthamii* tussock grassland with mixed herbland/ annual grassland.

On the slopes of the Fortescue Valley, the rail section passes through an area mapped by Beard as tree steppe (e16/24Lr.t1/3Hi) with *Eucalyptus leucophloia* and *Corymbia hamersleyana* (referred to *E. brevifolia* and *E. dichromophloia* in Beard) as the dominant trees. At a very broad level, such vegetation is not uncommon, but the associations within it vary greatly and this part of the rail section has varied vegetation.

In the Chichester Plateau, the Mt Leal section crosses Beards shrub-steppe of Kanji (*Acacia pyrifolia*) over *Triodia* and smaller amounts of his short grassland unit (XGc). Beard's short grassland unit is a mosaic of many plant communities on cracking clay. The different plant communities in this unit mostly occur as small areas with sharp boundaries. This vegetation has value not only for the diversity of plant communities within it, but also for the species that are restricted to the soil type it is developed on. While the vegetation on cracking clay has communities that are widespread, it also has significant variation within the Fortescue Botanical District. This variation also includes large areas within the Chichester Plateau. It was noticed that not only did the cracking clay vegetation in the Mt Leal rail section differ from those in the George River rail section, but that areas of this vegetation outside the study areas had variation not found within it.

As the above discussion indicates, at the level of Beard's study, the vegetation within the Mt Leal rail section study area is a subset of that which occurs on the Chichester Plateau and a section that grades into the Fortescue Valley. The extremely broad nature of Beard's study compared to the analysis of this report is shown by the fact that forty two vegetation associations have been described in this study for the Mt Leal rail section and that most of these associations are themselves quite broad, each containing a number of plant communities. It is noteworthy that Beard's description of the vegetation of the Chichester Plateau makes no mention of the vegetation of the large creeks, which have vegetation that is dependent to varying degrees on the increased water availability in these habitats. The vegetation associations of the damp areas in creeks and rivers in the Chichester Plateau in the Mt Leal rail section also have particular value as they have much less weed invasion, particularly of **Cenchrus ciliaris* (Buffel Grass) than similar habitats in many parts of the Fortescue Botanical District. However, one site which has been used as a stock watering point did have Buffel grass in places.

A major component of the conservation value for vegetation of the Mt Leal rail section at a broad level relates less directly to the particular vegetation that is in it. While the Mt Leal rail section can be considered more or less in isolation on the basis of the vegetation types within it, the vegetation in the

Mt Leal rail section also has significant conservation value as a part of a much larger area that is relatively undisturbed. This area is the Millstream - Chichester National Park and areas adjoining it. In this context, the Mt Leal rail section and the areas adjoining it have remarkably little disturbance and therefore have significant conservation value. This value is less than the comparable value for the George River rail section, as the Mt Leal rail section does not cut directly across the Chichester Plateau and, unlike the George River rail section, would not bisect the Millstream - Chichester National Park. The Mt Leal rail section is some 40 kilometres long, is crossed by one high tension power line that has a little used track along it, is not crossed by any roads and has a few little used tracks dating from the time when parts of it were grazed as part of the former Millstream Station. This grazing history has introduced weeds (mainly **Cenchrus ciliaris)* into some parts of the large creeks in the section. It should also be noted that there are proposals to add the area crossed by the rail section south of the Millstream - Chichester National Park to the National Park (Corr., CALM, April 3, 1997).

Survey results and vegetation with particular conservation value

Forty vegetation associations from four supergroups have been described for the Mt Leal rail section in this report. They are described in the Vegetation Report. The supergroups represented in the Mt Leal rail section survey area are the prefix 2 (major and minor flowlines), prefix 5 (vegetation of iron bearing formations), prefix 6 (vegetation of valleys, plains, low foothills and escarpments) and prefix 8 (vegetation of the Chichester Ranges volcanic formations and derivatives) supergroups. These are described in detail in the associated Vegetation Report, and the frequency of occurrence of each vegetation association is tabulated.

At a very broad level, the vegetation recorded in the Mt Leal rail section is within the range of vegetation described by Beard (1975) for his Fortescue Valley and Chichester Range physiographic units and is similar to the southern part of the George River rail section.

At the level of description of vegetation provided in this report, it is possible to identify some of the vegetation associations described and individual stands of vegetation in the Mt Leal rail section survey area as having particular values that are not widespread or which are probably not widespread on current knowledge.

Fifteen of the vegetation associations only recorded from the Mt Leal rail section were only recorded at one site in that rail section during this survey. This rail section has vegetation that has values not present in the other rail sections. Two of these associations are so markedly different that they are of major conservation value. Association 2eb is likely to be of restricted occurrence, because it occurs at a site that has permanent dampness or open water in a major watercourse. This association has *Acacia farnesiana* and *Melaleuca* species over *Sida fibulifera* and has *Ammania auriculata* and *Lobelia quadriangularis* amongst the associated species. Association 2ea has vegetation with *Eucalyptus victrix* low open woodland over *Cyperus vaginatus* very open sedgeland over *Eriachne* aff. *festucacea* (MET 11,654) tussock grassland at site 373. This is one of a small number of vegetation stands known that has *Eriachne* aff. *festucacea* (MET 11,654) prominent in the vegetation. It is the largest such stand and has significant conservation value for this species, for the vegetation type and probably for other species restricted to wet habitats.

The other associations in the major and minor flowlines supergroup (prefix "2") that are only represented by one occurrence in the Mt Leal rail section for the survey (i.e. associations 2cc, 2d, 2db, 2eb and 2f) are also likely to be of fairly limited occurrence due to the fact that these habitats are not a large proportion of the landscape. However, these association are largely dominated by species which are widespread in the Pilbara in riverine habitats, such as *Eucalyptus camaldulensis*, *Eucalyptus victrix*, *Acacia ancistrocarpa*, *Acacia tumida* and the grasses *Themeda triandsa*, *Chrysopogon fallax* and *Triodia pungens*. Where the associations are not dependent on moist conditions, they are unlikely to be very restricted in distribution.

Other associations with a similar value which were recorded only once in the Mt Leal rail section are associations 3aa, 3ac, 3ae, 3an, 5h, 5j, 6ac, and 8bd. These associations are either variants of others in the Chichester Plateau and slopes into the Fortescue Valley or have similar associations on different geological types. They have limited significance.

Several vegetation associations were restricted to the Mt Leal rail section but were present at three or more sites. Some of these associations are moderately significant. For example, association 5jb is

uncommon on a regional basis because it has *Acacia xiphophylla* over *Triodia brizoides*. It is more usual for *Acacia xiphophylla* to be associated with Triodia longiceps or *Triodia pungens*. Association 8d is dominated by *Astrebla* species (Mitchell grass) grassland, which occurred at a number of sites over the various sections. However, the stands are usually small and have significant variation in species composition. Stands dominated by *Astrebla pectinata* also have particular value due to the nutritional value of Mitchell grasses for fauna.

Another group of associations present in the Mt Leal rail section contains vegetation types that were recorded in this study area and also in one other study area, but at relatively few sites (five or less). The most significant of these is association 5l which is also present in the George River section, with two occurrences in each of the two rail sections. This vegetation association has a hummock grass layer of *Plectrachne* sp. (MET 11,654) which appears to be undescribed and is confined to flat topped or gently sloping iron bearing outcrops. Somewhat less significant are associations 5kb and 6af. Association 5kb has *Melaleuca eleuterostachya* and *Acacia bivenosa* over *Triodia longiceps* and *Triodia wiseana* on erosional spurs. It was recorded at two localities, one in the Mt Leal rail section and one in the George River rail section. *Melaleuca eleuterostachya* vegetation is uncommon in the Chichester Plateau and the slopes leading up to it, but is not uncommon in some parts of the Hamersley Range, where there are calcareous soils. Association 6af occurred at one site in the Mt Leal rail section and one in the George River rail section (some other sites in this rail section had similar vegetation) and is dominated by *Triodia longiceps*. Due to the large size of the hummocks *Triodia longiceps* forms, this vegetation may also have importance as fauna habitat.

5.8.8 Rail corridor - Chichester Range: Hamersley Parrallel (Western) route

Regional assessment and conservation values based on Beard (1975)

When the Beard's map information for this section is plotted on 1:50 000 scale maps, it becomes obvious that in the area where the Hamersley Parallel rail section ends, Beard's map is somewhat inaccurate in the location of the existing rail lines in relation to the physiographic units. In fact, the centre of the north end of the Hamersley Parallel rail section is on the lower slopes of the Chichester escarpment except for the last kilometre, whereas Beard's map would suggest that several kilometres were on the Abydos Plain.

This section of the route begins in an area of Beard's "short grassland" vegetation unit (xGc) which is annual grasslands on cracking clay soils. This vegetation unit includes patches of the next unit and is very variable. The section then has an area of Beard's "shrub steppe" unit (coded as a2Sr.t1/3Hi by Beard), which has *Acacia pyrifolia* (Kanji) over *Triodia wiseana* and *Triodia pungens* (mostly the former in the study area). There are some small areas of the short grassland unit within this part of the rail section. The northern part, somewhat more than half, of this rail section is in more dissected country and has "Mixed snappy gum tree steppe and Kanji shrub steppe", coded as e16Lr.t3Hi/ a2Sr.t1Hi on Beard's map. This means it has either snappy gum (*Eucalyptus leucophloia*) or Kanji (*Acacia pyrifolia*) over *Triodia wiseana* or *Triodia pungens*; in the study area it was found to have mostly Kanji over *Triodia wiseana*. The very end of the Hamersley parallel rail section (the last kilometre) crosses Western Creek, a large seasonal creek that enters the Abydos Plain where the rail section crosses it. The vegetation of this part of the rail section is quite varied, including vegetation dominated by *Eucalyptus camaldulensis* and *Melaleuca argentea* (referred to *Melaleuca leucadendra* by Beard) which Beard describes for the "major creeks and rivers" of the Abydos Plain.

At a very broad level the vegetation recorded in the Hamersley Parallel rail section is within the range of vegetation described by Beard (1975) for the Chichester Plateau, with a small area at the north of the rail section typical of major creeks and rivers on the Abydos Plain. In other words, on the Chichester Plateau, the Hamersley Parallel section has large areas of vegetation that correspond to Beard's *Acacia pyrifolia* shrub steppe and smaller areas that correspond to Beard's short grassland and tree steppe units. At the level of Beard's study, the vegetation within the Hamersley Parallel rail section is, then, a subset of that which occurs over the Chichester Plateau and in the major creeks of the Abydos Plain. The extremely broad nature of Beard's study is shown by the fact that twenty three vegetation associations have been described in this report for the Hamersley Parallel rail section and that these associations are themselves quite broad, each containing a number of plant communities. It is noteworthy that Beard's description of the vegetation of the Chichester Plateau

makes no mention of the vegetation of the large creeks that flow through it and which have vegetation that is dependent to varying degrees on the increased water available in these habitats. Some of the vegetation associations described for the Chichester Plateau in this report deal with these habitats.

A component of the conservation value for vegetation of the Hamersley Parallel rail section at a broad level relates less directly to the particular vegetation that is in it. While the Hamersley Parallel rail section can be considered more or less in isolation on the basis of the vegetation types within it, the vegetation in the Hamersley Parallel rail section also has conservation value as a part of a much larger area that is relatively undisturbed. This area is the Millstream - Chichester National Park and areas adjoining it. In this context, the Hamersley Parallel rail section differs markedly from the other three rail sections in the Chichester Plateau area in that at both ends it is adjacent or close to an existing rail line, only being a significant distance from that rail line in the central part of the section. While this does not negate the contribution of the vegetation of the Hamersley Parallel rail section survey area to the conservation value for vegetation of the Millstream - Chichester National Park, it does mean that construction of a rail line in this section would be much less intrusive than construction of the George River or Mt Herbert rail sections and would in effect widen a corridor through the Park rather than creating a new one.

Survey results and vegetation with particular conservation value

Twenty-three vegetation associations from four supergroups are described for the Hamersley Parallel rail section in this report. The supergroups in the Hamersley Parallel rail section are the prefix 2 supergroup (major and minor flowlines), prefix 5 (vegetation of iron bearing formations), prefix 8 (vegetation of the Chichester Ranges volcanic formations and derivatives) and prefix 9 (Vegetation of the Lyre Creek Agglomerate Member). The supergroups and associations are described in section five. These are described in detail in the associated Vegetation Report, and the frequency of occurrence of each vegetation association is tabulated.

Several of the vegetation associations described for the Hamersley Rail section in this report were not present in the other rail sections. These are associations 2b, 2ecla and 2eclb. While these associations were not recorded in the other rail sections they are not considered to be outside the general range of variation that would be expected in the vegetation of the Chichester Plateau and the small part of the Abydos Plain that the rail section contains. Another less common association, 2b, has dominant species such as *Corymbia hamersleyana*, *Acacia tumida* and *Triodia wiseana* , which are widespread. This association occurs in the area where the Hamersley Parallel, Mt Leal and Mt Herbert rail sections overlap, not at several localities. Associations 2ecla and 2eclb are close to 2ecl, but have *Eucalyptus camaldulensis* rather than *Eucalyptus victrix*. The difference does not make these associations of particularly great conservation value, because the former species is widespread along major flowlines. Association 2eclb also has *Terminalia canescens*, which is restricted to a few habitats in the Fortescue Botanical District, but is widespread, also occurring in the Kimberleys.

The areas of vegetation in the Hamersley Parallel rail section that are of most significance in terms of their conservation value are those that are restricted to the wetter areas of the streams. These include association 2eco, which is restricted to permanent seeps on major flowlines and has herbfields dominated by *Sesbannia cannabina*, *Ammania auriculata* and *Ludwigia perennis*. *Ludwigia perennis* is not common in the Fortescue Botanical District, and vegetation where it is abundant is quite unusual in that botanical district. However, the field work for this report has shown that similar stands occur sporadically (though not commonly) in the northern edges of the Chichester plateau. Another example of this association was recorded in the George River rail section. Similarly, association 2eclc is present on Mt. Herbert route, but may have conservation value because it features permanent water on major flowlines.

5.9. FLORA

As noted in Section 5.7 the flora information has been gathered from a range of sources which adopted different reporting styles and did not use a standard set of criteria to determine conservation values.

The flora survey for the West Angelas project area, access road and railway corridor were all undertaken by Trudgen and Casson (1998) who adopted a consistent approach to the assessment of

conservation values as described below.

Trudgen and Casson (1998) first considered general conservation value based on an assessment of the species diversity by comparing the size an area and the number of species contained within it. However, the limitations with using such an approach are recognised. For example, intensity of survey, seasonal conditions at the time surveys are undertaken and the variety of flora habitats (which depend largely on soil type, moisture availability/ position in the landscape) within a survey area all affect the number of species recored within a given area during a survey.

The general conservation value of an area can be influenced by the conservation value (i.e. rarity) of the species found in that area, but Trudgen and Casson (1998) assessed the conservation value of species within an area separately.

Assessing the conservation value of species within an area also has significant limitations. The rarity of a species often relates to the survey effort undertaken to look for populations of that species, and for some species the taxonomy has not yet been determined. For example, the current state of the taxonomy of some genera found in these surveys, such as *Sida* and *Hibiscus* does not enable assessment of the conservation value of species of these genera. *Desmodium* sp. (M.E.T. 16,191) is an example of a species which has a difficult taxonomy and for which there is little information about its distribution, but although only found at one site it would be premature to state that it is rare. As previously noted, survey effort in the Pilbara has been limited to broad scale mapping and a few site specific surveys.

For the flora, two principles should be used to make such conservation status assessments in the absence of specific searches for particular species. These are firstly, that if a species is not well collected or otherwise well known, then it should be presumed to be not common until known otherwise. The alternative is to risk impacting the populations of uncommon or rare species. Secondly, the best people to make judgements about the likely rarity of species are experienced taxonomic and survey botanists, who can judge the issue on the available evidence (number of collections, habitat preference, plant form, known distribution, knowledge of where a particular species has or has not been found), utilising their experience of making such judgements.

Given the difficulties with determining the conservation value status, information provided herein is limited to the survey results and is provided under the heading species of conservation interest.

The survey work undertaken for this project has undoubtedly changed the conservation value status of many species.

The following criteria have been developed by Hopper *et al.* (1990) for defining species which have a Declared Rare Flora (DRF) conservation value status.

- the taxon has been named under conventions of the International Code of Botanical Nomenclature;
- a reasonably thorough search has been made to locate wild populations and determine the number of plants present; and
- less than a few thousand reproductively mature plants are known to exist in the wild.

CALM is responsible for maintaining a list of all DRF and Priority (four categories) flora species (Atkins, 1996) (Table 5.1). Priority Species are those species not designated as DRF yet whose conservation status appears to warrant special legal protection. Priority species are maintained on a "Reserve List" and assigned to one of four Priority categories (Atkins, 1996).

Table 5.1: Definition of CALM Declared Rare and Priority Flora categories.

Code	Category	Definition
R	DRF	Declared Rare Flora - Extant Taxa. Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection.
X	DRF	Declared Rare Flora - Presumed Extinct Flora. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
1	Priority One	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat.
2	Priority Two	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat.
3	Priority Three	Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under immediate threat.
4	Priority Four	Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

The Department of Conservation and Land Management of Western Australia (CALM) maintains a list (Atkins 1997) of flora species that are either Declared Rare or are Priority species. Priority Flora are either poorly known, believed to be uncommon, rare or under threat but which have not been legally protected as Declared Rare Flora because the detailed survey work to justify this has not been carried out. The current version of the Declared Rare and Priority Flora List (Atkins 1997) was released on 4th December, 1997. During the identification of the plant specimens collected for this report, it became obvious that the portion of this list that applies to the Pilbara region of Western Australia is in a very preliminary state. While many of the species that are on the list, either as Declared Rare Flora or Priority Flora, deserve to be there, there are a number of Priority Species which the results of this study indicate should be removed and others which should have a lower ranking. There are also other species which are not present on the list and should be (some of these were not described before this survey).

The general conservation value, and species of conservation interest within an area have been considered under seperate headings where the reporting styles of the flora information provided enables such an approach.

In reading the flora sections it should be noted that except for the two orebodies within the West Angelas Survey area, direct impacts are largely going to be localised to narrow strips through the survey areas that will not impact most of the flora populations, including those of conservation interest.

5.9.1 West Angelas Survey Area

General conservation value.

A number of flora surveys have been undertaken in this area (Integrated Environmental Services 1978, Trudgen 1995a, 1995b and 1997).

Integrated Environmental Services (1978) recorded 98 flora species from 32 families.

During mid 1995 a comprehensive flora survey was conducted at Deposits A and B (Trudgen, 1995a; 1995b) recording 204 taxa of flowering plants and two species of ferns from 39 families at Deposit A and 215 taxa of flowering plants and four species of ferns from 44 families at Deposit B.

In the 1997 survey a total of 635 native flora taxa from 69 families were recorded.

It is considered that probably 85-95percent of the flora which occurs in the West Angelas survey area would have been recorded by these surveys.

Table 5.2 compares the number of flora recorded or estimated from some previous survey work to enable evaluation of the general conservation value of the West Angelas Survey area in relation to other areas in the Pibara.

Table 5.2: Number of flora recorded or estimated for some areas in the Fortescue Botanical District.

Survey or other area	Flora recorded or estimated (1)	Size	Other factors
Fortescue Botanical District (estimated here)	1 500 to 2 300 species	ca. 200 000 km^2	
Karajini National Park	481 species known in 1991, would expect 750 to 800 species	5 000 km^2	Park now slightly larger than in 1991.
Marandoo Project Area	462 species including 12 introduced, from 68 families	ca. 200 km^2	Range of habitats similar to West Angelas Survey Area.
West Angelas Survey Area	625 species from 69 families	420 km^2.	
Weeli Wolli area	302 species	150 km^2	Survey effort low, smaller range of habitats, but different habitats to West Angelas Survey Area.

(1) Data for the Marandoo Project area is from Mattiske (1992), for the Weeli Wolli Creek area from Trudgen (1984), for Karajini 1991 from Mattiske (1992), quoting unpublished data of Trudgen, current estimate by Trudgen.

From these comparisons it seems reasonable to conclude that the West Angelas Survey Area has a diverse flora for its size, but that this is due to it having a large range of relief and of geological types, these factors combining to provide a great diversity of plant habitat. A comparison between the Karajini National Park, Marandoo and West Angelas Survey Area suggests that the West Angelas survey area is of a size where the number of species per area recorded is high for areas of diverse habitat in the Hamersley Range.

The major point of interest then becomes how often does this combination of events occur through the Hamersley Range? There is no published data that can resolve this question. However, the particular diversity of habitat is not often repeated, as one of the large components is the presence of

large mulga stands in the West Angelas Survey Area and these do not occur west of Hamersley Station and the combination of geological types is quite diverse. Rainfall and the closeness to the southern side of the Fortescue Botanical District would also be factors. The West Angelas Survey Area falls in a part of the Hamersley Ranges that has higher rainfall than the western and eastern sections. The closeness to the southern side of the Fortescue Botanical District would explain why some families, such as Asteraceae and Myoporaceae, which are more common in the Ashburton Botanical District than the Fortescue Botanical District, have greater numbers in the West Angelas Survey area than in areas to the north.

Species of conservation interest

Taking into account results from earlier surveys, a total of 62 species of conservation interest are now known in the West Angelas Survey Area (see Table 5.3 below). One, *Lepidium catapycnon*, is a Declared Rare Flora species. Fifteen priority flora species were recorded, three priority one species, six priority two species, four priority three species and two priority four species. The remainder consists of eight species that had not previously been collected, twelve species not previously recognised as distinct but collected previously, three new records for the Fortescue Botanical District, seven poorly collected or uncommon *Cassia* taxa which are mostly hybrids, and sixteen other poorly collected or uncommon species.

Table 5.3: Species of conservation interest recorded from the West Angelas Survey area

Category and species recorded	No of sites & (significant flora sites)	Category and species recorded	No of sites & (significant flora sites)
Declared rare flora species		**New species: i.e. not collected before this survey**	
Lepidium catapycnon	1 (and outside survey area)	*Cynanchum aff. floribundum* (M.E.T. 15,941)	1
Priority Flora species recorded and their priority level (P1, P2 etc.)		*Desmodium* sp. (M.E.T. 16,191)	1
Eremophila caespitosa P1	9	*Euphorbia* sp. Harding (M.E.T. 15,683)	1 (756)
Josephinia sp. Marandoo (M.E.T. 1,554) P1	1	*Goodenia* aff. *cusackiana*	1
Goodenia stellata P2	9	*Hibiscus sturtii* var. aff. *truncatus* (site 1,016)	2
Ischaemum albovillosum P2	5 (756)	*Oldenlandia* sp. West Angelas (M.E.T. 15,919)	2 (756)
Olearia fluvialis P2	1	*Paspalidium* aff. *jubiflorum* (M.E.T. 15,807)	2
Olearia mucronata P2	1	*Sida* sp. (site 625)	2
Scaevola acacioides P2	11	**Species not recognised as distinct before this survey**	
Spartothamnella puberula P2	1	*Acacia* aff. *stowardii* (linear form)	1
Cynanchum sp. Hamersley P3	1	*Acacia* sp. West Angelas (M.E.T. 16,163)	1
Eremophila magnifica P3	1	*Cassia* sp. West Angelas (M.E.T. 16,115)	21
Indigofera gilesii ssp. gilesii P3	11	*Eriachne* aff. *mucronata* (fine species M.E.T. 12,737)	3
Triumfetta leptacantha P3	2	*Eriachne* aff. *benthamii* (M.E.T. 12,752)	1
Brachychiton acuminatus P4	2	*Myriocephalus* sp. Coondewanna Flats (S. van Leeuwin 975)	1
Tephrosia sp. Cathedral Gorge (F.H. Mollemans 2,420) P1	2	*Plectrachne* sp. Mt Ella (M.E.T.12,739)	7
Eucalyptus pilbarensis P4	3	*Rhynchosia* sp. Barowanna Hill (M.E.T. 15,623)	1 (756)
		Rhynchosia sp. Chichester (M.E.T. 15,225)	1

Category and species recorded	No of sites & (significant flora sites)	Category and species recorded	No of sites & (significant flora sites)
Species not recognised as distinct before this survey (continued)		**Poorly collected or uncommon taxa**	
Tephrosia aff. *clementii* (2)	2	*Acacia* aff. *catenulata*	> 11
Themeda aff. *triandra* (M.E.T. 16,046)	7	*Acacia* sp. (M.E.T. 15,650)	1
Themeda sp. Hamersley Station (M.E.T. 11,431)	3 (239) (756)	*Boerhavia paludosa*	4 (756)
New records for the Fortescue Botanical District		*Cassia artemisioides* (short leaflets)	1
Acacia minyura (MS)	3	*Cassia* sp. *Karajini* (M.E.T. 10,392)	6 (239)
Sida laevis	1	*Eremophila jucunda* ssp. *pulcherrima*	8
Vittadinia pustulata	1	*Eremophila platycalyx* ssp. *pardalota*	16
Poorly collected or uncommon Cassia taxa, mostly hybrids		*Hibiscus brachysiphonius*	1
Cassia ?oligophylla x *glutinosa*	1	*Indigofera fractiflexa* (ms)	11
Cassia aff. *pruinosa* (M.E.T. 15,687)	1	*Mukia* sp. D (F of A)	7 (756)
Cassia glutinosa x *'stricta'*	4	*Oxalis* aff. *corniculata* (site 654)	4
Cassia hamersleyensis x sp. *Karajini* (M.E.T. 10,392)	3 (239) (756)	*Pilbara trudgenii* (ms)	1
Cassia ?'glaucifolia' x *glutinosa*	2	*Pomax rupestris*	2
Cassia sp. aff. *'glaucifolia'* (site 888)	3	*Taplinia saxatilis*	3
Cassia sturtii x?	1	*Tricoryne trudgeni*	1
		Tripogon loliiformis var. 3 (SD 080.1)	2

The West Angelas Survey Area has a significant number (62) flora species that are of conservation interest. As a proportion of the flora known for the West Angelas Survey Area, about 10percent of the species are of conservation interest which is higher than for most survey areas probably reflecting the survey intensity and that there has been little collecting in the surrounding area.

The most significant records are *Lepidium catapycnon*, which is declared rare flora and those of *Euphorbia* sp. Harding (M.E.T. 15,683), *Oldenlandia* sp. West Angelas (M.E.T. 15,919) and *Goodenia* aff. cusackiana (site 1258). *Euphorbia* sp. Harding and *Oldenlandia* sp. West Angelas (M.E.T. 15,919) were first discovered during the field work for this survey.

Some taxa on the priority list have been shown by this survey to be considerably more common than previously known.

In the West Angelas survey area two sites were of particular interest for flora because they had several species of conservation significance. Both these sites were located on cracking clay where the vegetation structure was characterised by scattered low mixed shrubs over annual and perennial tussock grasses. Paradoxically, in dry periods both these sites would appear to be of very little interest as most of the flora species that appear after rain would only be present as seeds or root stocks. The two sites are site 756 near the west end of Deposit A and site 239 adjacent to the road between Deposit A and the Robe Camp at the base of West Angela Hill. Table 5.3 highlights these sites against species present.

The number of species of interest at these two sites suggests that some other areas of cracking clay in the West Angelas Survey Area may also have flora of conservation significance. A number of other sites were recorded on this habitat within the West Angelas Survey Area and some of the species of conservation significance were recorded on these sites. However, no other sites had as many of these species.

It is reasonable to suggest that the cracking clay habitat is of particular interest in the West Angelas Survey Area and any impact on it should be minimised.

Of the populations of the sixty-two species considered to be of conservation interest for the West Angelas Survey Area, most of the 62 species are unlikely to be directly impacted by the development. The West Angelas Survey Area is considered to have moderate or higher value for species of conservation interest.

5.9.2 West Angelas access road

Overall conservation value

The West Angelas access road survey recorded 157 species including one weed and a fern. The access road crosses relatively few flora habitats because it stays fairly low in the landscape. While some of the habitats crossed, particularly colluvial fans and low rises, are fairly species poor, the road also crosses a number of different Mulga types, some of which have moderate species diversity. The survey was of a fairly thin strip near the edge of the existing road, and a wider strip would result in more species being recorded.

The flora recorded was largely typical of the Hamersley Ranges in both the species recorded and the suite of families and genera present.

The overall conservation value for West Angelas access road for flora is low to moderate because of the low flora habitat diversity and the resultant low number of species recorded.

Species of conservation interest

One poorly collected and probably uncommon *Cassia* hybrid and one poorly collected *Eremophila* species were recorded from the West Angelas access road. The status of *Cassia glutinosa* x *"stricta"* is difficult to assess because of the difficulty of working in this genus. But while uncommon, the taxon (hybrid) is not rare. *Eremophila platycalyx* var. *pardalota* is quite poorly collected, but was recorded at twenty-one sites during this survey, mostly in the West Angelas Survey Area, but also in the Mount Robinson rail section. Although poorly collected, it is certainly not rare. The vegetation the road crosses has low value for species of conservation intrerest.

There were no sites with particular interest for species of conservation interest (i.e. having several such species) in the access road survey area.

5.9.3 Turee Creek Borefield

Overall conservation value

One hundred and forty six species, subspecies and varieties of vascular plants were recorded in the study area. All were flowering plants, except the fern *Cheilanthes sieberi* ssp. *sieberi*, a small fern commonly found under mulga stands or most areas with loamy soils.

The number of flora recorded is smaller than that recorded in a number of other Pilbara surveys probably due to the absence of species-rich habitats in the survey area, a low habitat diversity in the survey area, and the condition of the flora at the time of the survey. For example, there were no gorges or pools along the main creeks, and the mulga stands surveyed did not appear to be species rich. Many of the ephemeral plants which had been in flower and conspicuous several weeks earlier were no longer identifiable, or even visible. It is likely that in the order of 65percent to 75percent of the flora of the survey area have been recorded during this survey, with the annual flora particularly under-represented.

The flora recorded in the study area is largely typical of the flora of the Hamersley Ranges and to a lesser degree of the Pilbara.

Given the low flora habitat diversity in the study area and the relatively small flora recorded for it, this general conservation value for flora would reasonably be rated as low to moderate.

Species of conservation interest

No Declared Rare Flora or Priority Flora were recorded in the proposed borefield area.

Three species recorded in the study area are represented in the Western Australian Herbarium collections by only a few specimens, or have restricted distributions (but may be locally common). These species are *Oxalis* aff. *corniculata*, *Rhagodia* sp. Hamersley and *Eremophila compacta*.

Eremophila compacta was found to be locally common although it is apparently restricted in distribution. The population of *Eremophila compacta* found in the study area is the only one precisely known and the study area is the only locality where the species is known to have a large population. Consequently, on current knowledge the study area has high conservation value for this species. This needs to be tempered by the fact that this species has not been specifically searched and the fact that the more intensive field work in the West Angelas area (Trudgen and Casson 1997), from which this species is known, did not locate this species suggesting that it is uncommon there. It should possibly be placed on the CALM Priority Flora list at a low level (three or four). Further details about these species are provided in Weston and Trudgen (1997).

The study area also has conservation value for those species that are either uncommon or restricted in distribution. Thus it has particular conservation value for *Rhagodia* sp. Hamersley, *Eremophila compacta* and *Oxalis* aff. *corniculata*. While not common or widespread, neither *Rhagodia* sp. Hamersley nor *Oxalis* aff. *corniculata* are rare, with both being known from a number of populations. Therefore, while the study area has particular conservation value for these two species the level of this is not very high.

There is the possibility that Declared Rare Flora, Priority Flora or other species of interest not recorded during this survey occur in the survey area. Such species include *Acacia* aff. *catenulata*, *Brachychiton acuminatus*, *Flaveria* sp. Tom Price, *Josephinia* sp. Marandoo and *Scaevola acacioides* but others could also be present. Trudgen and Casson (1997) have discussed an extensive list of such species in, or potentially in, the West Angelas study area.

One hybrid between two *Cassia* species was recorded, with one of the parents (*Casia pruinosa*) not recorded in the survey.

5.9.4 Gas pipeline to West Angelas

The methodology for the survey gas pipeline survey (Weston, 1997) is the same as the borefield survey and is described in Section 5.7.2, above.

General conservation value

Two hundred and fifty species, subspecies, varieties and recognised forms of vascular plants were recorded in and near the pipeline corridor. The size of the flora recorded is similar to that of a number of other Pilbara floras. The flora recorded is estimated to be 70percent to 85percent of the flora occurring in the corridor and is largely typical of the flora of the Hamersley Range and adjacent area.

Two habitats contributed a large proportion of the flora diversity. One habitat is Vegetation Unit 2e, in the only gorge and with the only pools in the proposed pipeline corridor at the time of the survey, and the other is Vegetation Unit 1a, mulga low woodland in the northern part of the corridor. The flora of Vegetation Unit 2e is widespread in the Hamersley region, but the flora of Vegetation Unit 1a has species which are either poorly represented in the Hamersley region or are geographically restricted including *Acacia* aff. *catenulata, Brachychiton gregorii, Acacia* aff. *aneura, Grevillea* sp. and *Oxalis* aff. *corniculata.*

Dominant vegetation in Vegetation Unit 1a are *Acacia aneura* var. (green, flat; MET 15,946), *Acacia* aff. *catenulata, Acacia aneura* (ASW a2a: thick medium terete) low woodland, low open forest and high shrubland (mostly groved) over *Eremophila forrestii, Eremophila latrobei* subsp. *glabra* scattered low shrubs over *Eragrostis pergracilis, Aristida contorta, Aristida inaequiglumis* tussock grasslands, *Ptilotus helipteroides, Rhodanthe charsleyae* herbfields and *Triodia pungens, Plectrachne melvillei* hummock grasslands.

Species of conservation interest

No Declared Rare or Priority Flora was recorded in the proposed pipeline corridor.

Four species recorded in the proposed pipeline corridor are represented in the Western Australian Herbarium collections by few specimens or have restricted distributions (but may be locally common). These species include *Acacia* aff. *catenulata, Acacia aneura* var. (green, flat; MET 15,946), *Grevillea* sp. and *Oxalis* aff. *corniculata.* A fifth species of particular interest is *Brachychiton gregorii*, which is not commonly recorded in the Pilbara but which is widely distributed and locally common south and east of the Pilbara, particularly in deserts. Further details about these five species are provided in Weston (1997).

5.9.5 Rail corridor - Coondawanna West

General conservation value

Three hundred and thirty two species were recorded for the Coondewanna West rail section, of which one is a weed and four are ferns. This section crosses a variety of flora habitat types, including several Mulga types (on colluvial fans and in broad flow areas), colluvial fans and streams, but not as many as the Mt Robinson rail section for which it is an alternative to the southern half. The flora recorded along this rail section was largely typical of the flora of the Hamersley Ranges, in both the species recorded and the suite of families and genera present.

The general value for flora of the Coondewanna West rail section survey area is moderate because of the significant but not unusually high number of flora species recorded and the variety of flora habitat it contains. However, this value is not uniform for the length of the rail section, with some areas having higher value. The areas of Mulga vegetation crossed by this rail section are quite

diverse, with a variety of associated flora suites. The general conservation value for flora of the Mulga stands crossed is moderate to high, with the less common types (those along broad flow areas, some of which partly approach the claypan type habitat) being of moderate to high value.

Species of conservation interest

Three priority species, seven species not recognised as distinct before this survey, two new records for the Fortescue Botanical District and four poorly collected or uncommon taxa, one of which is a *Cassia* hybrid, were collected from the Coondewanna West rail section survey area. Table 5.4 lists species of conservation interest recorded from the Coondewanna West rail section with their interest category the number of sites at which they were recorded, and the sites of signifigance.

Table 5.4: Species of conservation interest recorded from the Coondewanna West rail section.

Category and species recorded	No of sites & **(significant flora sites)**	**Category and species recorded**	No of sites & **(significant flora sites)**
Priority Flora species recorded and their priority level (P1, P2 etc.)		**New records for the Fortescue Botanical District**	
Goodenia stellata P2	1	*Acacia minyura*	4
Brachychiton acuminatus P4	1 (but 23 in rail corridor)	*Vittadinia pustulata*	1
Eucalyptus pilbarensis P4	1 (903)	**Poorly collected or uncommon Cassia taxa, mostly hybrids**	
Species not recognised as distinct before this survey		*Cassia* sp. aff. *'glaucifolia'* (site 888)	1
Abutilon sp. West Angela Hill (M.E. Trudgen 16,132)	2 (920), (954)	**Poorly collected or uncommon taxa**	
Cassia sp. West Angelas (M.E.T. 16,115)	2	*Eremophila platycalyx* ssp. *pardalota*	1
Eriachne sp. aff. *benthamii* (M.E.T. 12,752)	2	*Oxalis* aff. *corniculata* (site 654)	1
Hibiscus aff. *sturtii* (site 903)	1 (903)	*Trianthema* aff. *kimberleyi* (M.E.T. 15,060)	1
Myriocephalus sp. Coondewanna Flats (S. van Leeuwin 975)	1		
Themeda sp. Mt Barricade (M.E.T. 2,471)	2		
Themeda sp. Hamersley Station (M.E.T. 11,431)	2		

The most significant records are the three priority species, two species which occur on restricted habitats namely *Abutilon* sp. West Angela Hill (M.E.T. 16,132) and *Myriocephalus* sp. Coondewanna Flats (S. van Leeuwin 975), and *Hibiscus* aff. *sturtii* (site 903) which was only collected once during the survey and is only represented in the Western Australian Herbarium by one specimen (see Table 5.4 above). *Abutilon* sp. West Angela Hill (M.E.T. 16,132) is only known from three collections.

Three sites were of particular interest for flora, namely sites 920 and 954 where *Abutilon* sp. West Angela Hill (M.E.T. 16,132) was collected (two of the three known locations for this species), and site 903 where *Eucalyptus pilbarensis* (P4) and *Hibiscus* aff. *sturtii* (site 903) were collected (sse Table 5.4).

The Coondewanna West rail section has moderate value for species of conservation interest, with particular value for *Abutilon* sp. West Angela Hill (M.E.T. 16,132) and *Hibiscus* aff. *sturtii* (site 903).

5.9.6 Rail corridor - Marandoo Corridor

Overall conservation value

Flora was first collected on the Marandoo Tenement in 1974, by the Western Australian Herbarium (Trudgen, 1975). A number of surveys have been conducted since (CRA Services Limited, 1982; Trudgeon, 1977a, 1977b, 1978; Weston, 1977) including systematic surveys conducted in 1990 and 1991 for Hamersley Iron Pty. Ltd. (Mattiske & Associates, 1992). These surveys included opportunistic sampling of the access corridors to the North-east and South-west (Hamersley Iron Pty. Limited, 1992).

By 1991 a total of 68 plant families and 462 vascular plant species had been recorded in the Marandoo Project Area (Hamersley Iron Pty. Limited, 1992).

Species of conservation interest

No flora species found in or near the Marandoo Project Area were declared as Rare Flora (Mattiske & Associates (1992).

Six species in or near the Marandoo Project Area were reported as Priority Flora Species and these are still listed in the Declared Rare and Priority Flora list. Four of these species - *Brachychiton acuminatus* (P4), *Eremophila magnifica* (P3), *Olearia fluvialis* (P2) and *Olearia mucronata* (P2) - were recorded within or adjacent to the Marandoo Lease Area during the 1991 field programme. *Acacia daweana* (P2) and *Acacia effusa* (P2), while not recorded in the 1991 survey, were reported in earlier surveys in the area. All six species may occur in suitable habitat within the Rail Corridor Area (Mattiske & Associates, 1992).

Mattiske & Associates (1992) listed a further thirty seven flora species recorded in the Marandoo area which can be considered geographically restricted, poorly collected, poorly known or restricted to small populations on very specific habitat. Eight of these species are now listed on the Declared Rare and Priority Flora list (Atkins, 1997). These species and their current Priority listing are *Cynanchum* sp. Hamersley (P3), *Dicladanthera glabra* (P2), *Flaveria* sp. Tom Pice (P3), *Indigofera ixocarpa* ms (P2), *Josephinia* sp. Marandoo (P1), *Polymeria* sp. Hamersley (P3), *Sida* sp. Marandoo (P3) and *Triumfetta leptacantha* (P3). *Flaveria* sp. Tom Pice and *Polymeria* sp. Hamersley were both recorded from the north-western section of the rail corridor (Mattiske & Associates, 1992). Although the other six species were not recorded from the rail corridor, in many cases suitable habitat exists and these priority species may be present.

The other 29 significant flora species reported by Mattiske & Associates (1992) were *Abutilon* spp., *Abutilon* sp. 3, *Boerhavia* sp. A, *Boerhavia* sp. B, *Brachyachne convergens*, *Bulbine* sp., *Crotalaria benthamiana*, *Cuphonotus andraeanus*, *Eremophila petrophila*, *Eucalyptus* aff. *coolabah*, *Eucalyptus ferriticola*, *Euphorbia* sp. 1, *Euphorbia* sp. 2, *Glossostigma* ? *diandrum*, *Goodenia* sp. 1, *Goodenia* sp. 2, *Lobelia* sp., *Maytenus* sp., *Olearia* sp., *Pandorea doratoxylon*, *Phyllanthus* sp., *Pimelea holroydii*, *Rottboellia formosa*, *Sida* spp., *Solanum* aff. *ferocissimum*, *Stenopetalum decipiens*, ?*Trianthema* sp., *Tricoryne* sp. and *Triodia* sp. nov. Although these species are not listed as Priority species the conservation status of many of them is still uncertain.

A number of sites were recognised by Mattiske & Associates (1992) as being of conservation significance due to the presence of Priority or species of conservation interest. Sites pertaining to the rail corridor included:

- cracking clays;

- localised pockets on and adjacent to volcanic outcropping areas;
- several gullies in the south-east transport corridor; and
- Oakover formation in the north-west of the south-east transport corridor.

5.9.7 Rail corridor - Hamersley Station Flats: Four Corners Bore

General conservation value

One hundred and thirty two species were recorded for the Four Corners Bore rail section of which six are weeds and one is a fern. This rail section crosses a variety of flora habitat types, including several Mulga types (on colluvial fans and at the margins of a plain), colluvial fans, streams and a small part of large plain with clayey soils (including areas of cracking clays) over calcrete material. The northern part of the section is amongst ranges, the southern part through low rises and the centre skirts the edge of and crosses a small part of a large plain that lies east and south-east of Hamersley Station homestead ("Hamersley Homestead Plain"). This rail section was comparatively dry when visited, which will have reduced the list of flora recorded by a small amount.

The flora recorded is largely typical of the flora of the Hamersley Ranges in most of the species recorded and the suite of families and genera present.

The general value for flora of the Four Corners Bore rail section survey area is moderate because of the significant but not unusually high number of flora species recorded and the variety of flora habitat it contains. However, this value is not uniform for the length of the rail section, with some areas having higher value. The small part of the large plain crossed has moderate to high value due to the comparatively small area of this habitat type that exists, particularly the areas of *Themeda* sp. Hamersley Station grassland and areas with calcrete near the surface (at the northern edge of the plain).

Species of conservation interest

Two priority three species, two species not collected before this survey, two species not previously recognised as distinct before this survey, one new record for the Fortescue Botanical District and three poorly collected or uncommon species were recorded in the Four Corners Bore rail section during this survey (see Table 5.5).

The most significant records are the two priority species, *Glycine falcata*, *Themeda* sp. Hamersley Station (M.E.T. 11,431) and *Acacia* aff. tumida (site 1175). *Glycine falcata* appears to be restricted to the Chichester Plateau and Hamersley Homestead Plain and it also occurs interstate. This species is edaphically restricted and is known from only two other two localities in Western Australia other than the ones recorded during this survey. *Themeda* sp. Hamersley Station (M.E.T. 11,431) is of particular interest because this is the largest and only known large population of this species where it is a dominant species. *Acacia* aff. *tumida* (site 1175) is a large shrub to eight meters tall and is only known from the one collection. This part of the Hamersley Ranges is fairly difficult to access and very poorly collected. It is likely that *Acacia* aff. *tumida* (site 1175) is localised rather than extremely rare.

In addition, the part of the rail section that crosses the Hamersley Homestead Plain is suitable habitat for some priority species that are present or abundant on it and that are uncommon elsewhere in the Fortescue Botanical District. These include *Bulbine pendula* (ms), *Themeda* sp. Hamersley Station (M.E.T. 11,431), *Polymeria* sp. Hamersley (M.E.T. 11,353), *Plantago* sp. Hamersley (M.E.T. 11,207) and *Astrebla lappacea*. Of this group of species, only the *Polymeria* and the *Themeda* were recorded during the survey.

Table 5.5: Species of conservation interest recorded from the Four Corners Bore rail route

Category and species recorded	No of sites & (significant flora sites)	Category and species recorded	No of sites & (significant flora sites)
Priority Flora species recorded and their priority level (P1, P2 etc.)		**New records for the Fortescue Botanical District**	
Polymeria sp. Hamersley (M.E.T. 11,353) P3	4	*Acacia minyura*	1
Triumfetta maconochieana P3	1 (32 sites in total recorded)	**Poorly collected or uncommon taxa**	
New species not collected before this survey		*Cassia* sp. *Karajini* (M.E.T 10,392)	1
Acacia aff. *tumida* (site 1175)	1 (1175)	*Glycine falcata*	2 (4 sites in total recorded)
Hibiscus sp. (site 316)	1	*Indigofera fractiflexa* (MS)	1
Species not recognised as distinct before this survey			
Tephrosia sp. Bungaroo Creek (M.E.T 11,601)	3		
Themeda sp. Hamersley Station (M.E.T 11,431)	3		

The most significant locations for flora where the railway crosses the Hamersley Homestead plain and site 1175, where *Acacia* aff. *tumida* (site 1175) was collected.

The Four Corners Bore rail section survey area is considered to have moderate value for species of conservation interest, but has high conservation value for *Acacia* aff. *tumida* (site 1175) and *Glycine falcata*. It also has low to moderate value for *Themeda* sp. Hamersley Station but this species is abundant on other parts of the Hamersley Homestead Plain.

5.9.8 Rail corridor - Mt Leal

General conservation value

The number of taxa recorded for this survey area was 335, of which three are weeds and four are ferns. This rail section crosses a large variety of flora habitat types including large areas of cracking clay soils, areas of a stony plateau, Snakewood (*Acacia xiphophylla*) stands, small valleys between low hills and small and larger streams, including some with permanent pools and damp areas. The south-eastern part of the section is on the slopes of the Fortescue Valley and the north-west section is on the Chichester Plateau.

The flora recorded is largely typical of the flora of the slopes of the Fortescue Valley and the Chichester Plateau in both the species recorded and the suite of families and genera present.

The general conservation value for flora of the Mt Leal rail section survey area is moderate because of the significant but not unusually high number of flora species recorded and the variety of flora

habitat it contains. However, this value is not uniform for the length of the rail section, with some areas having higher value. The areas of higher value are the large areas of cracking clays on the Chichester Plateau which have a significant number of edaphically restricted species such as *Crotalaria benthamiana* and *Hibiscus trionum* var. *vesicariusis*, and the areas of pools and damplands in the larger creeks (see below).

Species of conservation interest

Two priority one flora species, two priority two flora species, one priority three flora species and one priority four flora species were recorded during the survey of the Mt Leal rail section survey area. In addition, two new species not recorded before this survey, four species not previously recognised as distinct, four new records for the Fortescue Botanical District and nine poorly collected or uncommon flora taxa, one of which is a *Cassia* hybrid, were recorded (see Table 5.6).

The most significant records are the six priority species, *Desmodium* aff. *campylocaulon* (M.E.T. 15,606), *Acacia* sp. (M.E.T. 15,650) and *Paspalidium retiglume*.

Desmodium aff. *campylocaulon* (M.E.T. 15,606) should be considered a new, poorly collected, uncommon species with restricted distribution. *Acacia* sp. (M.E.T. 15,650) is represented in the Western Australian Herbarium by only one specimen (B.R. Maslin 2734) from a location 75 miles from Wittenoom towards Roebourne. It was also recorded in the West Angelas Survey Area. There is only one collection of *Paspalidium retiglume* in the Western Australian Herbarium. This distinctive species was collected in the George River, Mt Leal and Mt Herbert rail options, but appears to be quite uncommon.

The sites where *Acacia* sp. (M.E.T. 15,650), *Desmodium* aff. *campylocaulon* (M.E.T. 15,606), *Phyllanthus aridus* and *Paspalidium retiglume* were recorded are of particular interest because these species, particularly the *Acacia* and the *Desmodium*, are uncommon. Three sites are of interest because four of the priority flora or other species of interest were recorded at each. These are sites 404C, 404D and 407, which are cracking clay sites and have groups of species which are restricted to this soil type.

Given the number of priority flora species and other species of interest recorded, the Mt Leal rail section survey area has moderate value for species of conservation interest.

Table 5.6: Species of conservation interest recorded from the Mt Leal rail section.

Category and species recorded	No of sites & (significant sites)	Category and species recorded	No of sites & (significant sites)
Priority Flora species and their priority level (P1, P2 etc)		**New records for the Fortescue Botanical District**	
Phyllanthus aridus P1	3 (484), (496), (510) (10 sites in total recorded)	*Corchorus aestuans*	1
Tephrosia sp. Cathedral Gorge (F.H. Mollemans 2,420) P1	4	*Eragrostis exigua*	1
Ischaemum albovillosum P2	2	*Fimbristylis cephalophora*	1
Scaevola acacioides P2	1	*Neptunia monosperma*	1
Flaveria sp. Tom Price (M.E.T. 11,246) P3	5 (404C), (404D), (407)	**Poorly collected or uncommon Cassia taxa mostly hybrids**	
Brachychiton acuminatus P4	1	*Cassia hamersleyensis* x sp. Karajini (M.E.T. 10,392)	1
New species not collected before this survey		**Poorly collected or uncommon taxa**	
Desmodium aff. campylocaulon (M.E. Trudgen 15,606)	3 (404D), (405), (407)	*Acacia* sp. (M.E.T. 15,650)	1 (465)
Oldenlandia sp. Mt Montagu (M.E.T. 15,027)	1	*Boerhavia paludosa*	5 (404C), (404D)
Species not recognised as distinct before this survey		*Cyperus dactylotes*	1
Rhynchosia sp. Barowanna Hill (M.E.T. 15,623)	13 (407)	*Eragrostis crateriformis*	1
Rhynchosia sp. Chichester (M.E.T. 15,225)	10	*Eriachne* sp. aff. *festucacea*	3
Tephrosia sp. Bungaroo Creek (M.E.T. 11,601)	2	*Oldenlandia* sp. *'gilgai'*	14 (404C)
Themeda sp. Hamersley Station (M.E.T. 11,431)	1	*Paspalidium retiglume*	1 (404D)
		Trianthema aff. *kimberleyi* (M.E.T. 15,060)	2

5.9.9 Rail corridor - Chichester Range: Hamersley Parallel (Western) route

Generall conservation value

The number of taxa recorded for Hamersley Parallel (Western) rail section survey area was 315, of which seven are weeds and one is a fern. This rail section crosses a variety of flora habitat types,

including large areas of cracking clay soils, areas of a stony plateau, small valleys between low hills and small and larger streams, including some with permanent pools and damp areas. Most of this rail section is on the Chichester Plateau, with the north-western section coming down the escarpment to join the existing Robe River Iron Associates rail line.

The flora recorded is largely typical of the flora of the Chichester Plateau in both species recorded and the suite of families and genera present.

The general conservation value for flora of the Hamersley Parallel rail section survey area is moderate because of the significant but not unusually high number of flora species recorded for it and the variety of flora habitat it contains. However, this value is not uniform for the length of the rail section, with some areas having higher value. The areas of higher value are areas of cracking clays on the Chichester Plateau which have a significant number of edaphically restricted species such as *Crotalaria benthamiana* and *Hibiscus trionum* var. *vesicarius* and the areas of pools and damplands in the larger creeks and sometimes in gullies.

Species of conservation interest

One priority one species, two priority three species, one priority four species, four species not previously collected, three species not previously recognised before this survey, one new record for the Fortescue Botanical District and seven poorly collected or uncommon species were recorded during the survey of the Hamersley Parallel rail section survey area (see Table 5.7).

The most significant records are the four priority species, *Schoenus falcatus*, *Abutilon* sp. B, *Acacia* aff. *morrisonii*, *Acacia* sp. (site 1149), *Kennedia* sp. Barowana Hill (M.E.T. 15,617) and *Eragrostis* sp. Mt Montagu (M.E.T. 15,246).

Schoenus falcatus is a large, perennial sedge that grows in permanent pools and permanently damp areas. It was recorded at two sites and is quite uncommon in the Fortescue Botanical District. *Abutilon* sp. B, *Acacia* aff. *morrisonii* and *Kennedia* sp. Barowana Hill (M.E.T. 15,617) seem to represent or are new species. *Acacia* sp. (site 1149) is an uncommon hybrid and *Eragrostis* sp. Mt Montagu (M.E.T. 15,246) is a new species that was also recorded in the George River rail section.

Two sites, namely Sites 1117 and 1123 were of particular interest because they had five and four priority species and other species of interest respectively. Other places of particular interest along this rail section are the creeks with permanent pools because of the species that only occur in this habitat.

Given the number of priority flora species and other species of interest recorded, the Hamersley Parallel rail section survey area has moderate value for such species. In this context, it should be noted that some of the priority species and other species of interest, including some of the newly discovered and newly distinguished species, have been shown, by this survey, to be not uncommon in appropriate habitat.

Table 5.7: Species of conservation interest recorded from the Hamersley Parallel rail section.

Category and species recorded	No of sites & (significant sites)	Category and species recorded	No of sites & (significant sites)
Priority Flora species and their priority level (P1, P2 etc)		**New records for the Fortescue Botanical District**	
Tephrosia sp. Cathedral Gorge (F.H. Mollemans 2,420) P1	6	*Fimbristylis cephalophora*	5 (1117), (1123)
Triumfetta appendiculata P3	7 (1123)	**Poorly collected or uncommon taxa**	
Triumfetta maconochieana P3	7	*Acacia* sp. (site 1149)	1
Brachychiton acuminatus P4	7	*Amyema* sp. aff. *bifurcata*	2
New species; i.e. not collected before this survey		*Eriachne* sp. aff. *festucacea*	3 (1117), (1123)
Abutilon sp. B	1	*Fimbristylis rara*	1
Acacia aff. *morrisonii*	2 (1117)	*Mukia* sp. D (F of A)	1
Eragrostis sp. Mt Montagu (M.E.T. 15,246)	2	*Schoenus falcatus*	2 1117), (1123)
Oldenlandia sp. Mt Montagu (M.E.T 15,027)	14	*Trianthema* aff. *kimberleyi* (M.E.T. 15,060)	1
Species not recognised as distinct before this survey			
Hibiscus aff. *platychlamys* (site 1139)	2		
Kennedia sp. Barowana Hill (M.E. Trudgen (15,617)	1		
Rhynchosia sp. Chichester (M.E.T 15,225)	1		

5.10 TERRESTRIAL FAUNA

5.10.1 Introduction

The fauna assessment provided within the ERMP is produced by drawing upon a significant literature database, including both published and unpublished information, and recent focused intensive sampling (*ecologia*, 1998).

5.10.2 Previous studies

Due to the extensive iron ore deposits in the eastern Pilbara, the West Angelas project area and surrounding region has been the subject of a number of fauna surveys in the past 19 years. For example, Integrated Environmental Services conducted a fauna survey at West Angelas as early as 1978, recording three macropod and three bat species, 48 bird, one amphibian and 13 reptile species.

Detailed fauna surveys have been undertaken more recently in nearby project areas (e.g. Yandi (*ecologia*, 1995), Hope Downs (*ecologia*, 1996a) and Weeli Wolli Creek (*ecologia*, 1996b)). The Yandi survey recorded 154 vertebrate species, comprising 20 mammal, 81 bird, three amphibian, 47 reptile and three teleost fish species. The Hope Downs survey recorded 158 species comprising 24 mammal, 88 bird, one amphibian and 45 reptile species, and the Weeli Wolli survey recorded 133 species, comprising 15 mammal, 85 bird, three amphibian and 30 reptile species.

Fauna monitoring has been undertaken as a component of a Mulga research programme conducted by CALM in The Governor - Mt Robinson - Coondawanna Flats area to the immediate north and east from the proposed West Angelas mine site (CALM Woodvale, unpublished data).

A fauna study was also undertaken in the Karijini National Park in 1980 (Muir, 1983). In this study, 250 fauna species were recorded. Also within Karijini National Park, O'Brien & Associates Pty Ltd (1992) recorded a total of 243 species comprising 39 mammal, 118 bird and 86 reptile fauna species.

5.10.3 Survey Methodology

Vertebrate fauna assessment surveys of the project area were undertaken between June and October 1997 (*ecologia*,, 1998). Following a preliminary reconnaissance, detailed survey sites were chosen as being:

(i) representative of major fauna habitats;

(ii) areas of conservation value or ecological sensitivity; and/or

(iii) areas of environmental impact arising from proposed mining or related activities.

The number of sites and habitat types surveyed and the standard site design for the mine area and each rail corridor section are summarised in Table 5.8. Fauna survey sites were distributed throughout the key project areas (see Appendix C).

Table 5.8: Trapping Sites within the West Angelas Project Area. (*ecologia*, 1998)

	Survey Period in 1997	No. of Sites	No. of Habitats	Site design
Mine Area	10/6 - 23/6	13	6	CALM Pilbara grid
Rail Corridors				
Coondewanna West	23/6 - 26/6	4	3	Corridor site
Mount Robinson	28/9 - 3/10	7	5	Corridor site
Four Corners Bore	23/9 - 28/9	5	4	Corridor site
Mount Leal	30/6 - 10/7	3	3	Corridor site
Mount Herbert	30/6 - 10/7	9	7	Corridor site
Chichester Western	18/9 - 21/9	19	3	Helicopter survey site

Mine area

Assessment of the terrestrial vertebrate fauna was carried out using a variety of sampling techniques, including systematic and opportunistic sampling. The fauna sites within the West Angelas Mine Area were surveyed using CALM survey grid design (10 pits, 20 Elliott traps for 5 nights) which is shown in Figure 5.5. Thirteen sites within six major fauna habitats were sampled.

Systematic sampling: refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically facilitating comparisons within and among sites.

Opportunistic sampling: includes data collected non-systematically within and outside fixed sampling sites.

Systematic Data

Mammal, Reptile & Amphibian Fauna

(1) Pit-trap and drift fence: PVC piping (16 cm diameter., minimum 35 cm deep) and 20 L plastic buckets (30 cm diameter, 40 cm deep) were set into the ground. Each pit was equipped with a 5 m flywire drift fence (30 cm high) and baited with Universal Bait (rolled oats, peanut paste, honey, sardines).

(2) Elliott box traps: Within each systematic site, two parallel lines of 10 medium sized Elliott traps (9 x 9 x 32 cm) were arranged, and baited with universal bait.

(3) Searching: Systematic sites and all major habitats were hand searched for cryptic species. Foraging techniques included identification of active animals, raking leaf and bark litter drifts, raking bulldozer spoil heaps along existing tracks and survey lines, over-turning logs and stones, searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and recording tracks, diggings and scats.

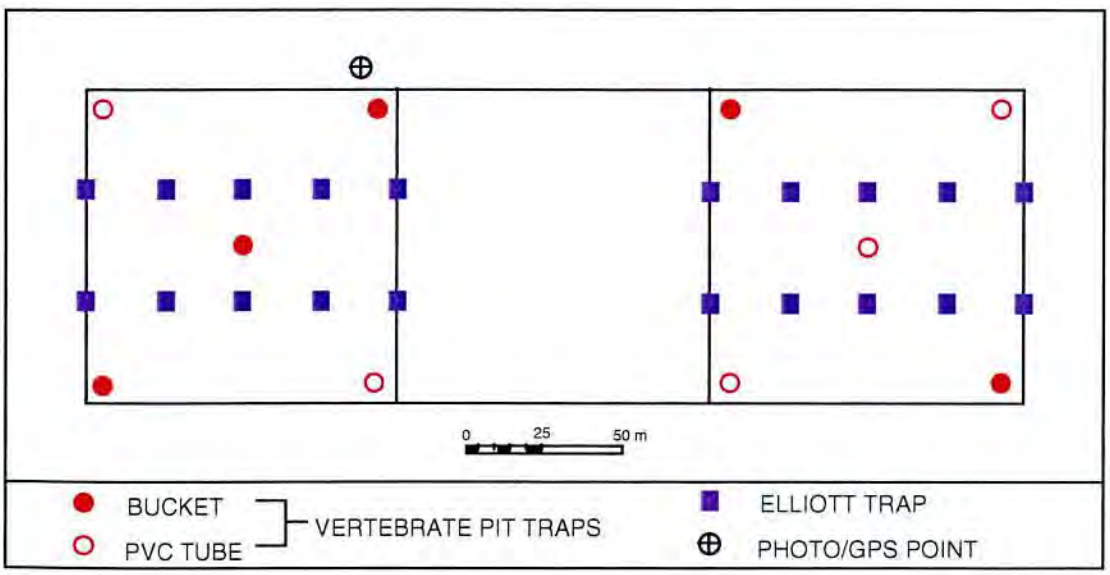


Figure 5.5: Fauna Survey Grid Design (based on CALM Pilbara Research Programmes).

Bird Fauna

Systematic censuses were used to survey the avifauna present at each fauna site. These censuses involved recording all species and individuals of each species over the duration of the census at a site. The surveys were designed to cover as much ground as possible within the vegetation type representative of that found in the fauna site. All surveys were consistent with techniques used in

other Pilbara surveys carried out by *ecologia* in order to facilitate meaningful comparisons.

Opportunistic Data

To supplement the systematic sampling outlined above, the presence of species in all vertebrate groups were assessed via:

(1) Secondary evidence: Tracks, diggings, scats, burrow and nests were recorded where possible for the species responsible.

(2) Opportunistic sightings: The presence of species was recorded while searching, travelling and during trap establishment within the project area.

(3) Spotlighting: Some sites were searched at night using head torches and hand held spotlights for nocturnal species such as geckoes and snakes.

(4) Mistnetting: Where suitable microhabitats occurred (pools of water and caves), bats were captured using mistnets, or observed *in situ* in caves.

Rail corridor

Within the rail corridor trapping was undertaken in the Coondewanna West, Mt Robinson, Four Corners Bore, Mt Leal and Mt Herbert sections. The entire length of the rail corridor was not surveyed in detail because the current survey was restricted to areas that were considered to represent the greatest potential environmental impact, namely those sections not following existing transport infrastructure alignments such as excision corridors, rail corridors or roads.

Rail corridor sites were surveyed by a combination of five pits and 20 Elliott traps for a period of five nights. PVC piping (16 cm diameter, minimum 35 cm deep) and 20 L plastic buckets (30 cm diameter, 40 cm deep) were utilised as pit traps. Elliott traps were used as described above. The five pit traps were laid out in a linear fashion and two lines of ten Elliott traps were laid parallel and to either side of the line of pit traps. Surveys of avifauna were consistent with those carried out in the Mine Area.

The survey of the Western Route section of the rail corridor within Chichester National Park was facilitated by the use of helicopter transport. Time and logistical constraints restricted sampling at each landing site to a census of the avifauna for one hour and at least one hour of opportunistic sampling for reptiles. In addition, a total of 50 Elliott traps were laid out at three locations along the route.

Table 5.9: Trapping effort within the West Angelas Project Area

Project Area	Pit trap nights	Elliott trap nights	Microhabitat Searching Effort
Mine Area	590	1380	29 hrs 30 min
Rail Corridor			
Coondewanna West	60	240	16 hrs
Mount Robinson	110	440	16 hrs 15 min
Four Corners Bore Route	120	480	15 hrs 15 min
Mount Leal	65	360	4 hrs 30 min
Mount Herbert	320	1180	11 hrs
Western Route	-	150	13 hrs
Total Rail	675	2850	73 hrs
TOTAL	1265	4230	105 hrs 30 min

5.10.4 West Angelas Mine Area

Systematic sampling and opportunistic collecting yielded a total of 119 vertebrate species including 19 native and three introduced mammal species, 70 birds, 27 reptiles, and one amphibian. A search of the Western Australia Museum fauna database and data obtained from Cliffs International (1978) indicate that an additional two marsupial, three bat , six bird, two amphibian and 38 reptile species have been recorded previously from the Mine Area.

It is unlikely that all potential species would be detected within the West Angelas Mine Area during the course of a biological survey due to temporal and spatial variations in population numbers. Faunal population fluctuations are the result of differing biological and physical factors. Several species are nomadic or migratory (e.g. honeyeaters and waterbirds) and may only be expected in the area after substantial rain (e.g. waterbirds) or at certain times of the year (e.g. Fork-tailed Swift *Apus pacificus* and Rainbow Bee-eater *Merops ornatus* would be expected only between late September to April). Other species would only be likely to occur in the area after local proliferation of food resources (e.g. honeyeaters during extensive and prolific flowering of shrubs).

Populations of resident fauna species fluctuate between different seasons and years, while certain species respond to local differences in fire regime and hence successive vegetation developmental stages. In particular, resident species with naturally low population densities (e.g. Grey Honeyeater *Conopophila whitei*) are difficult to detect.

Data is available from two other sources in the West Angelas Mine Area. These include Western Australian Museum records (WAM) and a previous survey of the Mine area (Cliffs International, 1978). Additions to the species list can be made from these sources to include species not present at the time of this survey or not sampled.

Two of the bird species, the Grey Honeyeater *Conopophila whitei* and the Grey Falcon *Falco hypoleucos*, are listed on Schedule 1. Three reptile species are interesting in that they are uncommon in the area, namely *Heteronotia planiceps*, *Heteronotia splea* and the Black-headed Python *Aspidites melanocephalus*. Another species of interest is the Pilbara endemic *Lerista neander*, which is only found in a small area of the Pilbara.

Fauna Habitats

The system of habitat classification used is the current landform classification system devised by Dawe and Dunlop (1983) during the fauna survey of Karijini National Park. Although Fauna habitats are closely aligned with landform - vegetation associations, they are, in the majority, a composite of several associations. The vegetation of the thirteen systematic fauna sites varies to some degree between sites that are grouped as the same habitat, however, there are overall similarities in the primary factors affecting animal distribution, i.e. landform, soils, vegetation structure and composition. Six fauna habitats were identified as being representative of both the landform features and vegetation associations of the Mine Area.

The Mulga Woodland is particularly rich in bird species, with 45 species, or 65 percent of the total bird species recorded in the West Angelas Mine Area. Mulga Woodland habitat provides structural diversity, as well as shelter and nesting sites, and suitable foraging areas for many species, particularly small passerines not recorded elsewhere, e.g. Thornbills *Acanthiza* spp., Varied Sittella *Daphoenositta chrysoptera*, and Western Gerygone *Gerygone fusca*. The lizards *Caimanops amphiboluroides* and *Varanus gilleni* are also generally restricted to Mulga Woodland habitat.

Rocky Gully habitat occurs primarily along the edge of hills where major drainage lines have formed. During periods of heavy rainfall water is washed from the hills, through the gorges and on to the outwash plains. Rocky Gully habitat consists of steep-sided areas of exposed rock and fallen boulders, which are important refuges and foraging areas for saxicoline (rock-inhabiting) reptiles, often with sandy areas at the base of the gorge along the drainage line proper. Gorge habitat supports a distinctive array of reptile species including the saxicoline nocturnal geckos *Gehyra punctata* and *Oedura marmorata*, and the skink *Morethia ruficauda exquisita*. The Rock Rat *Zyzomys argurus* is also commonly found in this habitat, sheltering in rock crevices during the day, and was common in the project area. The insectivorous Little Woodswallow is also most frequently encountered in Rocky Gully habitat.

Cracking Clay habitat occurs in a number of low lying areas on the plain of the mine area. This habitat is characterised by deeply cracked clay soil dominated by an assortment of grasses. Scattered Mulga trees merge into open Mulga Woodland at the edge of Cracking Clay areas. Although this habitat had the lowest predicted species diversity, it had the third highest observed number of species, of note was the large number of birds at these sites, the second highest number of species for all habitats. Only three species of mammal were recorded in this habitat. Although Cracking Clay habitat is expected to support a large number of reptile species, only three species were observed during the survey. This is partially due to the large number of hiding places for skinks and lizards in the cracks, which can be up to a metre deep.

Creekline habitat (Sites 6 and 10) is found along several creeklines in the project area. These areas are vegetated with scattered *Eucalyptus gamophylla* and *E. leucophloia* over low *Triodia wiseana* on stony soils. This habitat had the equal highest expected species richness, but only 33 species were recorded. Few birds were recorded in this habitat; only 19 species were recorded out of an expected 99. The House Mouse *Mus musculus* was exceptionally common in this habitat, accounting for 76percent of mammals captured at the two sites.

Hilltop habitat typically has a substrate of exposed rock or skeletal soils overlying rock. Vegetation generally consists of scattered *Eucalyptus leucophloia* and *Acacia* species over *Triodia wiseana*. Animals that shelter under rocks including the lizards *Varanus acanthurus*, *Ctenotus pantherinus* and *C. saxatilis* are commonly recorded in this habitat. Spinifex clumps are also important refuge sites for fauna. The high content of pebbles in the soil makes this habitat suitable for the Pebble Mound Mouse *Pseudomys chapmani*. Common bird species include Weebill *Smicrornis brevirostris* and Rufous-crowned Emu-wren *Stipiturus ruficeps*.

Spinifex Steppe habitat is widespread across the higher areas of the plain within the project area. These *Triodia* dominated areas contain scattered trees such as *Casuarina* and *Eucalypt* species. The soil is gravelly with occasional rock outcrops and is suitable for the Pebble Mound Mouse

Pseudomys chapmani, five were caught in this habitat. The White-winged Fairy-wren *Malurus leucopterus* was abundant in this habitat, particularly in a thickly vegetated drainage gully that passed through the centre of the site.

Mammals

Twenty one species of mammal were recorded during the field survey, 19 of which were native and two introduced (Appendix C). Seven families were represented in the native fauna including the Tachyglossidae (echidna) (one species), Dasyuridae (carnivorous marsupials) (six species), Macropodidae (kangaroos and wallabies) (three species), Canidae (dingo), Megadermatidae (Ghost Bat) (one species), Emballonuridae (Sheathtail-bats) (one species), Vespertilionidae (true bats) (two species) and Muridae (rats and mice) (four species).

The increasingly rare Ghost Bat *Macroderma gigas* was recorded within the Rocky Gully habitat. This species is particularly sensitive to disturbance, and although population densities appear to be stable in the Northern Territory (where it is a protected species), numbers in Western Australia are thought to be in decline. This species is listed as Priority three on the Western Australian Fauna List.

Of regional significance, the Lakeland Downs Mouse *Leggadina lakedownensis* was collected from the Cracking Clay habitat (four specimens).

Spinifex Steppe produced five Pebble-mound mice, this habitat being ideal for mound formation with an extensive pebble substrate.

Birds

A total of 70 species of bird, comprising 25 non-passerines and 45 passerines, were recorded during the West Angelas survey (Appendix C). Thirty families were represented in the avifauna, with the Accipitridae (kites, hawks and eagles), Columbidae (pigeons and doves), and Psittacidae (parrots) making the greatest contribution to species richness within the non-passerines, while the Meliphagidae (honeyeaters), Pardalotidae (thornbills, pardalotes and weebill) and Maluridae (wrens) dominated the passerines. In terms of number of individuals, the Passeridae (finches) were the most numerous, followed by the Meliphagidae (honeyeaters) and Pardalotidae (thornbills, pardalotes and weebill).

A total of 46 bird species were recorded from Mulga Woodland habitat, comprising 65 percent of the total for the West Angelas Project Area and 24 percent of all individuals recorded. Fifteen of these species were recorded exclusively from this habitat during the biological survey. The large number of species recorded exclusively from this habitat is partly due to the large proportion of the project area covered by Mulga Woodland, with the result that many species were recorded opportunistically within this habitat. Species usually confined to this habitat within the Pilbara include White-browed Babbler *Pomatostomus superciliosus*, Western Gerygone *Gerygone fusca*, Slaty-backed Thornbill *Acanthiza robustirostris*, and Chestnut-rumped Thornbill *A. uropygialis*.

Many species were recorded from only one habitat type including the White-backed Swallow *Cheramoeca leucosternus* in Creekline habitat and the Spotted Nightjar *Eurostopodus argus* from the Spinifex Plain habitat (Appendix C).

Reptiles and Amphibians

A total of 29 species of herpetofauna (frogs, lizards and snakes) from eight families were recorded within the West Angelas Mine Area during the survey period (Appendix C). The Scincidae (skinks) and Gekkonidae (geckos) made the greatest contribution to total species richness with eleven and six species. Three agamids (dragon lizards), three varanids (monitor lizards), four snakes, one pygopod (legless lizards) and one frog species were also recorded.

Species found exclusively within Mulga Woodland habitat included the Pilbara endemic *Delma elegans* and the as yet undescribed monitor *Varanus* sp., which is similar to the Pygmy Mulga Monitor *V. gilleni*.

Of particular interest from the Rocky Gully habitat was the single record of a Barking Gecko *Underwoodisaurus milii*, which has not previously been recorded from the Pilbara, and usually inhabits the south-west of the state.

5.10.4 Coondawanna Flats: Coondewanna West rail route

Fauna Habitats

Fauna sampling was conducted at four sites in the Coondewanna West area (Appendix C). Three fauna habitat types were sampled: Mulga Woodland (MW), Grassland (GR) and Spinifex Steppe (SS).

Fauna Sites CW1 and CW4 represented areas of Mulga Woodland habitat. This habitat type generally occurs on outwash plains at the base of hills, with an overstorey of Mulga *Acacia aneura*. Site CW1 consisted of dense Mulga over *Triodia* spp. whereas Site CW4 was only moderately dense with a chenopod understorey and patchy grasses grading into areas of Spinifex. The soil at these sites was a red loam with few rocks and pebbles.

Site CW2 was a large expanse of low grassland, which merged into areas of open Mulga over grasses at the periphery. The assorted grass species were sparse and less than 30 cm tall. The soil was a sandy loam. The site was characterised also by numerous widely spaced termite mounds standing up to 1 m tall.

Site CW3 represents SS habitat, located on an upland area on a rocky spur. The substrate in this habitat consisted of shallow sand over rock, with exposed boulders and skeletal soils. The vegetation was dominated by scattered *Eucalyptus leucophloia* over moderate to dense Spinifex *Triodia basedowii*.

Mammals

Nine mammal species were recorded from the Coondewanna West area, including eight native and one introduced species. Mulga Woodland provided the most mammal records, with five species: Pilbara *Ningaui N. timealeyi*, Euro *M. robustus*, Sandy Inland Mouse *P. hermannsburgensis*, House Mouse *M. musculus* and the Dingo *C. lupus dingo*. Three species were recorded from Grassland habitat.

Several individuals of the Ghost Bat *M. gigas* were observed roosting in a cave overlooking the Mulga plains through which the proposed railway corridor option would pass.

Birds

A total of fifty-eight species of bird were recorded in the Coondewanna West area, including 18 non-passerines and 40 passerines.

Mulga Woodland provides a structurally diverse habitat which can support many different species of bird. A surprising find in the Mulga Woodland was seven individuals of the Splendid Fairy-wren *Malurus splendens*. This species is an infrequent visitor to the Pilbara and there are few records of this species so far north in Western Australia. The ongoing CALM Mulga study in this area also recorded the Splendid Fairy-wren (Start & van Leeuwen, unpublished.).

Twenty-nine avian species were recorded in Spinifex Steppe habitat, including nine recorded exclusively from this habitat. Grassland habitat recorded the lowest number of avian species in the Coondewanna West section with only twenty-five species recorded. A species of note recorded in Grassland habitat was the Grey Falcon *Falco hypoleucos* which is a WA Schedule 1 species.

Reptiles and Amphibians

Few reptile species were active at the time of the Coondewanna West survey due to the cool weather experienced. Eleven species were recorded, including three geckos, one agamid, five skinks and two snakes. One animal was caught in a trap, the skink *Ctenotus pantherinus*, whereas all other recordings were made by opportunistic searching.

The highest number of reptile species were recorded in Spinifex Steppe habitat, since there was an abundance of larger stones and rocks for skinks and geckos to shelter under. Mulga Woodland recorded the second highest number of reptile species.

Other Data

Additional species recorded from Coondawanna Flats not present at the time of this survey or simply not sampled are available from several other sources. These include a long-term CALM Mulga project in the Coondawanna Flats locality (Start & van Leeuwen, unpub.), Western Australian Museum records (WAM) and previous surveys of the Coondawanna Flats Area (Cliffs International, 1978; Ninox, 1994).

Five additional mammal species (including two bat species) have been previously recorded in the Coondawanna Flats area. An additional 25 bird species have been seen in the Coondawanna Flats area (Start & van Leeuwen, unpub.; Cliffs International, 1978; Ninox, 1994).

Bird species recorded include the Fork-tailed Swift *Apus pacificus* (protected under JAMBA/CAMBA Treaties), Grey Honeyeater *Conopophila whitei* (Schedule 1 protected species) and species uncommon to the Pilbara such as the Black Honeyeater *Certhionyx niger*, Pied Honeyeater *Certhionyx variegatus* and Striated Grasswren *Amytornis striatus*. The Grey Honeyeater *Conopophila whitei* was also found nesting just outside the Coondawanna Flats region in Mulga Woodland (Start & van Leeuwen, unpub.), so it is quite likely that the Mulga Woodland in the Coondawanna Flats area is used for breeding as well.

Start & van Leeuwen (unpublished data, 1997) identified two frogs and 22 reptiles from their Mulga sites that were not recorded in this survey. Species of interest were the Pilbara endemics *Lerista neander* and *Lerista flammicauda*, which are only found in a small area of the Pilbara.

5.10.5 Marandoo Corridor

Karijini National Park has been the subject of several biological surveys in the past, including Muir (1983), Ninox (1992) and CALM (1995). These reports, taken together, represent an intensive bioassessment of the Karijini/ Marandoo corridor, the results of which are summarised in this section.

Data sources indicate that 244 vertebrate species have been recorded in the Marandoo Tenement/Rail Corridor, including 118 species of bird, 29 native mammals, 10 introduced mammals, six frogs and 81 reptiles. A review of the Hamersley Range National Park in 1980 recorded 133 bird species, 24 mammals, seven frogs and 86 reptiles. The lower number of mammals recorded in the latter survey is due to the exclusion of "larger" mammal species such as the macropods and introduced animals such as feral cats and cattle from the report.

Fauna Habitats

Five fauna habitats have been identified from the Marandoo Project Area report (Ninox, 1992). These were similar to habitat types found in other Rail Corridor areas, with the addition of Riverine and Snakewood habitats. The proposed rail corridor will run parallel to the existing Hamersley Iron rail route and therefore pass through the same habitats and have similar predicted impacts on the native fauna as those outlined in the ERMP for the Marandoo mine (Hamersley Iron Pty Ltd., 1992).

Mulga Woodland in the Marandoo Railway corridor comprised a low woodland of Mulga *Acacia aneura*, with scattered tall Eucalyptus species. Mixed shrubs and grasses make up the ground cover. The substrate was silty or clay loams with occasional rocky areas.

Eucalyptus Woodland was almost entirely uniform with an overstorey of *Eucalyptus coolabah* and a dense ground cover of the grass *Eulalia fulva*. Mixed sparse shrubs were also present. The soil was a silty clay loam.

Snakewood habitat was composed of predominantly Snakewood *Acacia xiphophylla*, and some mixed shrubs. The soil type was a clay loam with small rocks.

The Spinifex Steppe sites in the corridor were made up of hummock grasslands of *Triodia* spp. and *Pletrachne* spp. with few other mixed low shrubs. The substrate was a minor outwash with colluvial deposits of sandy loam.

A tall Woodland of *Melaleuca argentea* and *Eucalyptus camaldulensis* lined the banks of permanent water in the Riverine habitat. A fringe of Sedges was present at much of the water's edge. The substrate was mixed fine sand and rocks.

Mammals

Thirty nine mammal species have been recorded in the Marandoo rail corridor, including six species of dasyurid, three species of native rodents, thirteen bat species with representatives from five families and several macropods, including the Euro *Macropus robustus* and Rothschild's Rock-wallaby *Petrogale rothschildi*.

One species currently listed under the Wildlife Conservation Act, 1950 as Schedule 1 - Fauna which is rare or likely to become extinct have been reported from this area. Observations of *Macrotis lagotis* were based on burrow structures thought to have been dug by that species, and no specimens have been seen or collected. The Priority four species the Western Pebble-mound Mouse *Pseudomys chapmani* has been caught over a period of years in this area.

The Ghost Bat *Macroderma gigas* was found during two surveys (Ninox, 1992) and is currently listed as a CALM Priority 3 species, and is protected in other states of Australia.

Birds

A total of 133 species have been recorded from the rail corridor, including 73 non-passerines and 60 passerines (Muir, 1983).

Riverine habitat is the most important for birds within the Marandoo rail corridor and supports numerous species, some of which (e.g. Rainbow Bee-eater *Merops ornatus*) are usually confined to this habitat.

Three scheduled bird species have been found in Karijini National Park; Grey Falcon *Falco hypoleucos* (Schedule 1), Grey Honeyeater *Conopophila whitei* (Schedule 1) and Peregrine Falcon *Falco peregrinus* (Schedule 4).

Herpetofauna

A total of 92 species of amphibians and reptiles have been recorded within Karijini National Park (Muir, 1983). Of these, 87 were observed in the Marandoo tenement locality (Ninox, 1992). Water and pools support six species of frog and several reptile species inhabiting riverine habitats.

A number of Pilbara endemic reptile species were recorded in or around the Marandoo railway corridor and tenement, including the geckos *Diplodactylus savagei* and *Nephrurus wheeleri cinctus*, the dragon lizard *Diporiphora valens*, the skinks *Ctenotus duricola, C. rubicundus, C. rutilans and Morethia ruficauda exquisita*, the monitor *Varanus pilbarensis*, Pilbara Olive Python *Liasis olivaceus barroni* and the elapid snake *Demansia rufescens*.

One scheduled reptile species has been found in the Marandoo Corridor area to date, the Pilbara Olive Python *Liasis olivaceus barroni.*

5.10.6 Hamersley Station Flats: Four Corners Bore route

Fauna Habitats

Five systematic fauna survey sites were established within the Four Corners Bore route area. Three fauna habitats were recognised within the area: Mulga Woodland, Spinifex Steppe, and Cracking Clay.

Mulga Woodland habitat varied from a dense overstorey of Mulga *Acacia aneura* over a sparse understorey of soft grasses, on the northern part of the route, to a more open overstorey of Mulga over large clumps of Hummock Grass *Triodia wiseana*, south of Four Corners Bore.

Spinifex Steppe habitat was dominated by a ground cover of *Triodia wiseana* over calcrete. Overstorey species included Desert Bloodwoods *Corymbia opaca* and Snappy Gums *Eucalyptus leucophloia.*

Cracking Clay was dominated by an undescribed species of Kangaroo Grass (*Themeda* sp., M Trudgen 11431), grading into open shrubland dominated by *Acacia suberea.* Soils were red cracking clay soils of colluvial origin.

Mammals

Thirteen mammal species including three introduced species were recorded in the Four Corners Bore route area. Native species included three dasyurids, two macropods, two microchiropteran bats, and three species of rodent.

The Lakeland Downs Mouse *Leggadina lakedownensis* and *Planigale ingrami* were recorded only from the Cracking Clay habitat. Both species are restricted almost exclusively to this habitat.

Evidence of the Schedule 1 species Western Pebble Mound Mouse *Pseudomys chapmani* was found in the Spinifex Steppe habitat.

Birds

Fifty six bird species were observed in the Four Corners Bore Route area, including 23 non-passerines and 33 passerines. Thirty three species were observed within Spinifex Steppe habitat, 25 at Mulga sites and eight species within Cracking Clay habitat. Twelve species were observed opportunistically outside of fauna sites.

The most commonly recorded species within Cracking Clay habitat was Singing Bushlark *Mirafra javanica*, which was recorded only from this habitat. This species commonly lives in open country such as tussock grassland (Blakers et. al., 1984), and within the Pilbara generally occurs only within this habitat.

The Spotted Nightjar *Eurostopodus argus* a Priority 4 species was recorded in the Four Corners Bore route section of the rail corridor, is relatively common in the Pilbara region, and may be taken out of the CALM priority list when next updated (Allan Burbidge, CALM Woodvale pers. comm.).

Herpetofauna

Twenty two species of reptile were recorded within the Four Corners Bore Route area, including four

geckos, eight species of skink, four agamids (dragon lizards), four monitors and a single species of blind snake. Thirteen species were recorded in Spinifex Steppe habitat, 10 species were recorded in Mulga Woodland habitat and only one species was recorded at the Cracking Clay site.

No scheduled or priority listed reptile species were recorded within the Four Corners Bore Route.

Species of interest recorded include an as yet undescribed species of Mulga monitor, *Varanus* sp. nov. and the subspecies of the Knob-tailed Gecko *Nephrurus wheeleri cinctus* which is confined to the Pilbara region.

5.10.7 Southern Millstream - Chichester Range National Park: Mt Leal route

Fauna Habitats

Fauna sampling was conducted at three sites in the Mt Leal route corridor. These sites represented the three major habitat types found in this section: Spinifex Steppe (SS), Snakewood Woodland (AX) and Acacia Shrubland / Drainage (Dr).

Acacia Shrubland / Drainage habitat was dominated by an overstorey of very dense to moderate *Acacia* shrub sp over moderate *Triodia*. The area also included small patches of dense scrub of assorted shrubs over 1 m with occasional tall Eucalypts. Many of the flora species, including the *Acacia* species, were in flower and the area was of high structural diversity. The substrate was gravelly.

The Spinifex Steppe habitat was widespread on the gentle hills of the Mt Leal section. This habitat was composed of Eucalypt woodland over a moderate understorey of *Triodia* sp. The substrate was gravelly.

The Snakewood communities formed isolated pockets throughout this area. They were dominated by an overstorey of Snakewood *Acacia xiphophylla* of moderate density over a short grass understorey. The substrate was clay.

Mammals

A total of eight mammal species (seven native and one introduced) were recorded in the Mt Leal area. The native species recorded included four dasyurids, an euro and two rodents. The only introduced species was the House Mouse *Mus musculus*.

The Schedule 1 species, the Pebble Mound Mouse *Pseudomys chapmani*, was recorded from the *Acacia* Shrubland / Drainage habitat.

Birds

A total of 34 species of bird were recorded from the Mt Leal section. This included 11 species of non-passerine and 23 species of passerine. The limited number of habitat types and surveyed sites in this area is reflected in this data.

The Priority 4 species, the Spotted Nightjar *Eurostopodus argus* was recorded opportunistically from the Mt. Leal section.

Herpetofauna

The habitat in the Mt Leal section is unsuitable for frogs and no specimens were collected. Four species of reptiles were found in the area.

5.10.8 Chichester Ranges: Hamersley Parallel (Western route)

In this section a total of four habitats were identified and sampled by 20 sites. These were Grassland Steppe (Sg), Cracking Clay (CC), Riverine (RI) and Rocky Drainage Line (DRr).

The Grassland Steppe habitat was almost purely a *Triodia* grassland covering rolling basaltic hills of the Chichester Ranges. This distinctive landform, the rocky substrate and the near complete lack of trees differentiated it from *Triodia* dominated sites sampled in other areas. Extensive areas along the Harding River were sampled during the Western route survey, including upland areas of rocky Drainage Line and typical Riverine habitat with occasional permanent pools and fringing vegetation on the lower section.

Mammals

A total of six native and one introduced mammal species were recorded from the Hamersley Parallel (Western) route. The native species recorded included one dasyurid, two rodents, the dingo and two macropods. Although 20 sites were opportunistically sampled in this section, trapping was conducted at only three sites (Cracking Clay, rocky Drainage Line and Grassland Steppe habitat). The low number of species recorded relative to the other sections reflects this reduced level of systematic sampling.

The Pebble-mound Mouse was recorded from Drainage Line habitat.

Birds

A total of 57 species (26 non-passerine and 31 passerine) were recorded from the Hamersley Parallel (Western) route. A number of species were recorded only from the Riverine habitat. These species included the Rufous Night Heron *Nycticorax caledonicus*, Sacred Kingfisher *Todiramphus pyrrhopygia* and the Fairy Martin *Hirundo ariel*.

The Bush Thick Knee *Burhinus grallarius* - a Priority 4 species - was recorded in Riverine habitat.

Herpetofauna

Surveys of the Western route recorded two species of frog. One species, *Pseudophryne douglasi*, recorded from a permanent pool of water in Drainage Line habitat, is restricted to permanent pools and seeps in canyons in the Pilbara.

A total of 10 species of reptile were recorded, including *Lophognathus longirostris*, Ring-tailed Dragon *Ctenophorus caudicinctus*, Military Dragon *Ctenophorus isolepis* and Black-headed Python *Aspidites melanocephalus*. Within the Pilbara the Black-headed Python is usually encountered near water as was the case in this instance in which a single specimen was excavated from a burrow in sand in the vicinity of the Harding River.

Fish Fauna

Suitable fish habitats occur along the length of the Harding river and its tributaries where rail corridor passes through Millstream Chichester National Park. The fish fauna was not sampled within such habitats. From the known distribution of freshwater fishes in the area nine species can be expected to occur within the permanent pools of the Harding River and Western Creek (Allen, 1989). None of the fish species expected in the rail corridor areas are specially protected under State Legislation.

5.11 RARE AND SPECIALLY PROTECTED FAUNA

There are a number of fauna species which occur or may occur within the West Angelas Project Area which have been formally recognised as rare, threatened with extinction or as having high conservation value and are protected by law under Western Australian and Commonwealth Legislation. Within Western Australia the Wildlife Conservation Act 1950, incorporating the JAMBA is in effect. At the national level, fauna are protected under the Endangered Species Protection Act, 1992. CAMBA covers certain species of avifauna, particularly transequatorial waders. In addition fauna are covered under the April 1991 Australian & New Zealand Environment & Conservation Council (ANZECC) convention.

Fauna species which have been formally recognised as rare, threatened with extinction or as having high conservation value are specially protected by law under the Wildlife Conservation Act 1950. Classification of rare and endangered fauna under the Wildlife Conservation (Specially Protected Fauna) Notice 1996, which is maintained by CALM, recognises four distinct schedules:

(1) Schedule 1 "... fauna which is rare or are likely to become extinct, are declared to be fauna in need of special protection";

(2) Schedule 2 "... fauna which is presumed to be extinct, are declared to be fauna that is in need of special protection";

(3) Schedule 3 "... birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of special protection"; and

(4) Schedule 4 "...declared to be fauna that is in need of special protection, otherwise than for the reasons mentioned in paragraphs (a), (b) and (c)."

The Commonwealth Endangered Species Protection Act, 1992 has the purpose of promoting the recovery of endangered and vulnerable species and endangered ecological communities. The Act includes schedules of endangered, vulnerable and presumed extinct species based on those agreed to by the ANZECC at the time of the Act being proclaimed.

The Endangered Species Protection Act, 1992 has three schedules, with the first schedule containing a list of species that are endangered or vulnerable or that are presumed extinct. These second and third schedules provide for the listing of endangered ecological communities, and a list of key threatening processes respectively. The definitions for classification under Schedule 1 are:

- Presumed Extinct: an animal or plant species that has not been found in the wild during the last 50 years;
- Endangered: an animal or plant species which is in danger of extinction and will probably not survive if it continues to be threatened; or
- Vulnerable: an animal or plant species which will probably become Endangered if it continues to be threatened.

Some species which are not specifically covered by the Wildlife Conservation Act 1950 (Specially Protected Fauna) Notice 1996 are listed under four priority codes by CALM. The definition of those codes are:

Priority one	(P1)	Taxa with few, poorly known populations on threatened lands.
Priority two	(P2)	Taxa with few, poorly known populations on conservation lands.
Priority three	(P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority four	(P4)	Taxa in need of monitoring.

5.11.1 West Angelas Mine Area

WA Wildlife Conservation Act 1950

The Grey Honeyeater *Conopophila whitei*, Schedule 1, is rare and probably nomadic (Pizzey, 1997). It generally inhabits semi-arid Mulga woodlands or other *Acacia* scrub communities. This species has been recorded in Mulga habitat in the Mine Area in previous surveys (Integrated Environmental Services, 1978; Start & van Leeuwen, unpub.).

An unconfirmed observation of the Bilby *Macrotis lagotis* was made in the West Angelas Mine Area in 1979 (Dunlop, pers. comm.). The Bilby is regarded as locally extinct in the West Angelas Mine Area.

Three other Schedule 1 species potentially occur within the West Angelas Mine Area. They are the: Grey Falcon *Falco hypoleucos*, Orange Leaf-nosed Bat *Nycticieus aurantius* and the Pilbara Olive Python *Morelia olivacea barroni*

Remains of nests found in small caves and breakaways in the Mine Area indicated the historical presence of the Schedule 2 Lesser Stick-nest Rat *Leporillus apicalis*. The animal itself has not been officially reported since 1933 and is presumed extinct.

Two Schedule 4 bird species may occur in the West Angelas Mine Area although they were not recorded in this survey. The Peregrine Falcon *Falco peregrinus* was recorded within the Area C Project Area, 30 km north-east of the West Angelas Mine Area, during a recent biological survey (*ecologia*, 1997). The Major Mitchell's Cockatoo *Cacatua leadbeateri* is widely distributed throughout Australia and its status is considered to be "widespread but usually much less abundant than other white cockatoos" (Pizzey, 1997).

Endangered Species Protection Act 1992

The Ghost Bat *Macroderma gigas* is listed as Vulnerable and by the International Union for the Conservation of Nature (IUCN Red Data Book,1988). During the current survey four specimens of the Ghost Bat were recorded within the mine area from a cave near Deposit B. The species has also been previously reported from caves in Deposit E and Deposit B (Integrated Environmental Services, 1979) including a maternity cave area near Deposit E (Muir, 1983). The current status of the maternity cave is unknown as recent inspections have found no activity.

The greatest hazard facing Ghost Bats is the destruction or disturbance of roosting and maternity caves and entrapment on recently constructed barbed wire fences. Some specimens have been caught on barbed wire fences between BHP's Mining Area C and the West Angelas Exploration Camp (T. Start, pers. comm.). Maternity caves are particularly important because caves with suitable conditions for breeding are thought to be relatively uncommon.

Species Protected by International Agreements

The CAMBA listed species, the Fork-tailed Swift *Apus pacificus* potentially occurs in the Mine Area. Both species have been recorded in nearby areas (Start & van Leeuwen, unpublished data; Muir, 1983).

Priority Listed Fauna

Three Priority species were recorded in the West Angelas Mine Area: The Ghost Bat *Macroderma gigas* (P3) and the Western Pebble-mound Mouse *Pseudomys chapmani* (P4).

Other priority listed species that could be expected in the West Angelas Mine Area are the Long Tailed Dunnart *Sminthopsis Longicaudatus* (P4), Square Tailed Kite *Lophoictinia isura* (P4) and the

Bush Thick Knee *Burhinus grallarius* (P4).

Species of Regional or Local Significance

Species of regional or local significance include those that have restricted distributions, restricted habitat requirements, taxonomic uncertainty or have been recently discovered.

Of regional conservation significance is the Cracking Clay habitat which is relatively uncommon in the Pilbara. Areas of Cracking Clay have their own floristic composition and support specialist vertebrate fauna such as the Long-tailed Planigale *Planigale ingrami* and the Lakeland Downs Mouse *Leggadina lakedownensis*.

Although widspread in the south-west of Western Australia only a single specimen of Barking Gecko *Underwoodisaurus milii* was recorded from rocky habitat in the mine area representing a significant range extension.

The Splendid Fairy-wren *Malurus splendens* was recorded in Mulga Woodland in both the mine area and the Coondewanna West section of the rail corridor. This is a significant range extension on its generally Bassian distribution.

Habitats or Species of Local Significance

Mulga Woodland is also locally significant in that it can support a wide range of bird species, thereby allowing some species that are normally considered outside their distribution to be present, such as the Splendid Fairy-wren *Malurus cyaneus*.

Locally significant habitats within the West Angelas Mine Area also include the locations of Ghost Bat caves and surrounding areas as well as habitats that support a high density of Western Pebble Mound mice.

5.11.2 Marandoo Railway Corridor Area

WA Wildlife Conservation Act 1950

One Schedule 1 mammal species has been recorded in the Marandoo Railway Corridor. Whilst not caught or sighted, the burrows of the Bilby *Macrotis lagotis* were reported to be found in the area (Ninox, 1992).

Two Schedule 1 birds have been recorded in this section of the Rail Corridor : the Grey Falcon *Falco hypoleucos* and the Grey Honeyeater *Conopophila whitei*. The Grey Honeyeater *Conopophila whitei* has been observed breeding in the Mount Bruce area of the corridor. Potentially disturbance to the Mulga Woodland habitat in which they are breeding may affect this rare species locally, however the degree of impact which may occur is unknown at this stage.

One Schedule 1 reptile has been found in the Marandoo railway corridor, the Pilbara Olive *Python Liasis olivaceus barroni* (Muir, 1983). One other Schedule 1 species, the Orange Leaf-nosed Bat *Nycticieus aurantius*, potentially occurs within the Marandoo Rail Corridor.

The Schedule 4 Peregrine Falcon *Falco peregrinus* has also been observed in the area (National Parks, 1980). The Schedule 4 Major Mitchell's Cockatoo *Cacatua leadbeateri* is widely distributed throughout Australia.

Endangered Species Protection Act 1992

The Ghost Bat *Macroderma gigas* (ESPA Schedule 1) has been observed in the Marandoo Rail corridor.

Species Protected by International Agreements

Two species, the Fork Tailed Swift *Apus pacificus* and Rainbow Bee Eater *Merops ornatus* have been observed within the Marandoo corridor (National Parks, 1980; Ninox, 1992). These species are protected under the CAMBA treaty. These species are generally uncommon in the area apart from during migration months, when they can be present in large flocks.

Priority Listed Fauna

Both the Ghost Bat *Macroderma gigas* (P3) and the Western Pebble-mound Mouse *Pseudomys chapmani* (P4) were recorded in the Marandoo Railway Corridor. The Western Pebble-mound Mouse has been found many times and in different surveys (National Parks, 1980; Ninox, 1992).

Regional Conservation Significance

The Marandoo Railway Corridor consists a portion of land excised from the Karijini National Park. No fauna or fauna habitat types or landforms are restricted to the Railway Corridor and are therefore of minimal regional significance.

Local Conservation Significance

The large area of Mulga Woodland adjacent to Mount Bruce can be considered of local significance due to its utilisation by Grey Honeyeaters *Conopophila whitei* (Schedule 1) for breeding (Start & van Leeuwen, unpub. data).

5.11.3 Four Corners Bore route

WA Wildlife Conservation Act 1950

No Schedule 4 species were recorded in this section however both the Peregrine Falcon *Falco peregrinus* and the Major Mitchell Cockatoo *Cacatua leadbeateri* may occur in the area.

Endangered Species Protection Act 1992

No species protected under Commonwealth Legislation were observed within the Hamersley section of the rail corridor.

Species Protected by International Agreements

No species protected by international agreements were observed within the Hamersley portion of the rail corridor route. However, the Rainbow Bee-eater *Merops ornatus* and the Fork Tailed Swift *Apus pacificus* have both been recorded from elsewhere in the region and could utilise this area (Start & van Leeuwen, unpublished data; Muir, 1983).

Priority Listed Fauna

The presence of the Priority 4 listed species Western Pebble-mound Mouse *Pseudomys chapmani* on a detrital slope within the northern section of the rail corridor was inferred from the presence of an active mound.

Habitats or Species of Regional Significance

The large expanse of natural Cracking Clay that covers most of Hamersley Station is regionally significant in that such habitat is not well represented in the region and the area present on

Hamersley station represents the largest un-fragmented area of this habitat type in the Pilbara region.

The large expanse of natural Cracking Clay that covers most of Hamersley Station is locally significant in that it supports three species (Singing Bushlark *Mirafra javanica*, Long-tailed Planigale *Planigale ingrami* and Lakeland Downs Mouse *Leggadina lakedownensis*) which depend on this habitat. It also provides an optimal hunting ground for rodent specialists such as the Barn Owl *Tyto alba* which was recorded but is not frequently observed in the Pilbara region. The area is inundated on a seasonal basis and may also support an interesting amphibian fauna at such times.

The undescribed new species of Monitor related to *Varanus gillenni* and *V. caudilineatus* was recorded from Mulga Woodland on Hamersley Station.

5.11.4 Chichester Range & Mt Leal Sections

WA Wildlife Conservation Act 1950

The Western Pebble-mound Mouse *Pseudomys chapmani*, a Priority 4 species, was recorded in suitable habitat in both the Mt Leal (3 mounds) and the Western (1 mound) route sections.

The populations of Pilbara Olive Python *Morelia olivacea barroni* subspecies are restricted to the Pilbara region where they are most often encountered along major drainage systems, especially those associated with rock outcrops (Wilson and Knowles, 1988). While not recorded in the survey this species probably occurs within the Millstream Chichester National Park section of the proposed rail corridor.

No Schedule 4 fauna were recorded within this section although the Peregrine Falcon *Falco peregrinus* and the Major Mitchell Cockatoo *Cacatua leadbeateri* are possible.

Endangered Species Protection Act 1992

No species protected under Commonwealth Legislation were observed within the Western section of the rail corridor.

Species Protected by International Agreements

The Rainbow Bee-eater *Merops ornatus* was observed in the Western section of the Rail Corridor. This species is protected under the CAMBA treaty.

Priority Listed Fauna

One Priority 4 listed species the Bush Thick-knee *Burhinus grallinius* was recorded within this section of the rail corridor.

Species of Regional Significance

The *Leggadina lakedownensis* specimens recorded in the Cracking Clay and Drainage habitats in this area are under taxonomic review. It is likely that the Pilbara form is taxonomically distinct from those found in the Kimberley region (N Cooper, WA Museum pers comm). The restricted, isolated and low-lying nature of the Cracking Clay habitat increases their sensitivity to disturbance.

Pseudophryne douglasi is a Pilbara endemic restricted to the Hamersley, Chichester and Cape Ranges and inhabits permanent pools in the areas.

Habitats or Species of Local Significance

An area of local significance in the Chichester Range area is the Snakewood habitat (*Acacia xiphophylla*). This vegetation type is very localised, with few other representative areas in this area.

The riverine areas, including permanent pools within gorges and the Harding river, support a high number of birds including some that are usually associated within the Kimberley region. Those areas are the most locally significant within the Western section of the rail corridor.

The Cracking Clay habitat is locally significant in that it supports distinct fauna assemblages, is restricted to isolated and small areas and is susceptible to disturbance.

5.12 MARINE ENVIRONMENT

5.12.1 Overview of the Cape Lambert Marine Environment

The marine environment adjacent to Robe's shipping port at Cape Lambert is essentially that of a calcarenite based tidal mudflat, with some mangroves occurring in the area. The port occurs in a medium energy environment and is protected from the open sea by offshore rock reefs.

The bathymetry of the Cape Lambert region is that of a broad, shallow (<10 m) nearshore region with several exposed reefs and islands. Generally, this area is featureless sloping gently from the shore. Offshore, the bathymetry is complex with depths between 12 - 17 m and numerous reefs and shoals. These reefs are generally in 8 - 10 m of water and lie in an east-west orientation.

Three shipping channel routes provide continuous access to the wharf in at least 14 m of water. The departure channel from the wharf has been improved with dredging. Due to the prior construction of the existing jetty and ore loading pier, the marine and nearshore environment has already been altered by the associated land reclamation, dredging and construction activities.

There are four main marine substrate types in the project area. Most of the nearshore areas are characterised by silty sand, which becomes increasingly sandy as it extends onto the beach. A limestone pavement apparently underlies the sand (Kinhill Riedel & Bryne, 1991). This pavement is sometimes exposed to form rubble and rock reefs of <50 cm height. In places, this substrate extends onto the shore. The deeper offshore area appears to have sandy mud dominating the seafloor. Large rock and coral reefs are distributed throughout the area, many of which rise to be exposed at lower tidal levels or form permanent islands (e.g. Bezout Island.). Two minor substrate types were also identified. A shallow patch of very high cover coral reef exists on the south west part of Cape Lambert. The east of Cape Lambert has an extensive seawall built for the existing stockpile, which lies on top of the silty sand.

Studies, including an environmental study were undertaken in 1982 for the channel dredging and spoil disposal at Cape Lambert (Figure 3.8) (Maunsell & Partners, 1982 & Meagher and Associates, 1982). The studies concluded:

- the biological habitats which occured within the spoil disposal sites appeared to be widespread throughout the Cape Lambert coastal region;
- the sediments of both spoil grounds were relatively depauperate of epifauna (animals growing upon the surface), and the benthic fauna was limited to species tolerant of broad scale sediment movement and relatively high turbidity;
- compared to Mermaid Sound, the sediments of spoil grounds two and three were rated as moderately productive and extremely unproductive respectively; and
- given the nature of the dredge material, the spoil dumps were expected to be stable and pre-disposal diversities and abundance reached within three to 18 months.

Although re-colonisation was not monitored after 18 months, monitoring in 1997 found that the spoil dumps had been re-colonised.

A marine survey was undertaken for the purposes of the ERMP documentation (*ecologia*, 1997) and the results are summarised below.

5.12.2 Marine Flora and Fauna

Based on substrate types and biota, five marine and three coastal habitats were identified within the Cape Lambert section of the project area (see Figure 5.6):

Marine

(i) Silty Sand;

(ii) Shallow Rocky Reef;

(iii) Sandy Mud;

(iv) Coral Reef; and

(v) Rock Wall.

Coastal

(vi) Sedimentary Shore;

(vii) Rocky Shore;

(viii) Oceanic; and

(ix) Mangroves.

Details of each habitat are provided below and are illustrated in Figure 5.6.

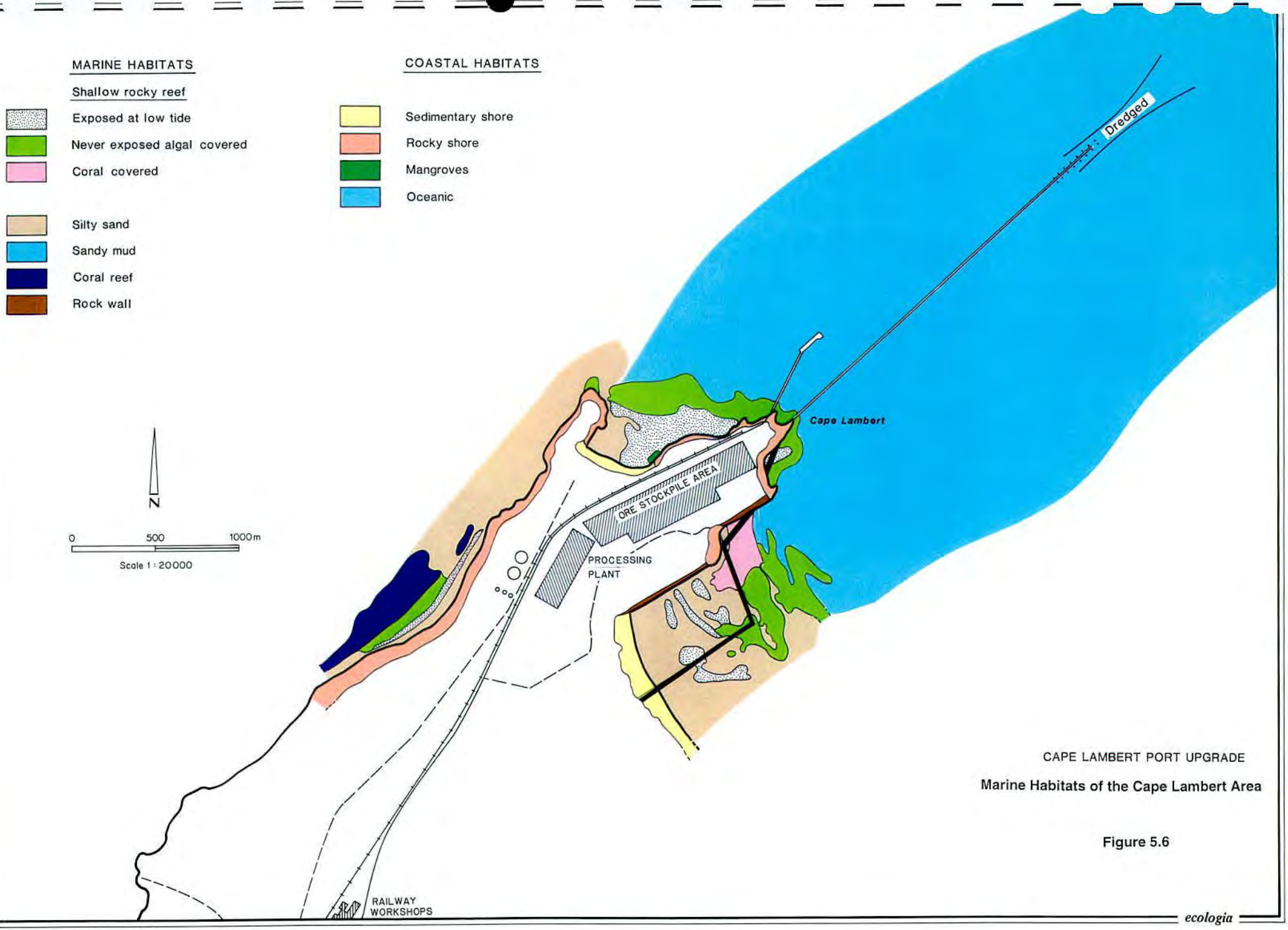
Silty Sand

Silty Sand was the dominant intertidal habitat, occurring on the west and east sides of the Cape. Most of the Silty Sand habitat on the east was exposed at low tide. Sand in deeper water in the vicinity of the Coral Reef habitat remained submerged. The sediment was predominantly sandy, showing a seaward gradation from typical coarse beach sand to finer silts. At low tide, this habitat forms an extension of the Sedimentary Shore habitat.

Biologically, the habitat allow only those species which are mobile (and can move with the tide) or are tolerant to daily desiccation. At high tide much of the sand is tinged brown by diatomaceous algae coating the surface of the sand. There are occasional sea-anemones, sea-cucumbers, numerous annelid tube-worms (up to 100 worms per m^2), gastropod molluscs including mud-whelks (family Potamididae), moon-snails (Naticidae), dog-whelks (Nassariidae) and mitres (Mitridae), bivalve molluscs including razor-shells (Pinnidae), cockles (Cardiidae) and the uncommon watering pot shell (Clavagellidae). Squid (Idiosepiidae) were observed during high tide.

Some 112 individual fishes from 14 species were recorded from the Silty Sand, making it one of the least diverse habitats. However, the fish fauna of this habitat comprised almost exclusively species which feed on the incoming tide. Both Green Turtles *Chelonia mydas* and Hawksbill Turtles *Eretmochyles imbricata* were recorded over the Silty Sand.

Since the Silty Sand and Sedimentary Shore habitats are almost continuous at low tide, it is necessary to consider the bird fauna combined. Importantly, within this habitat half of the species (41 percent



CAPE LAMBERT PORT UPGRADE

Marine Habitats of the Cape Lambert Area

Figure 5.6

of individuals) and their habitats are protected under international agreements. Many of these species are specialist mud-feeders.

Shallow Rocky Reef

The Shallow Rocky Reef habitat comprised the remainder of the intertidal region, and the shallower parts of the subtidal region. It is therefore subdivided into three zones: (i) exposed rubble at low tide; (ii) never exposed and algal covered; and (iii) never exposed and coral covered.

These reef areas arose where the limestone pavement was higher than the surrounding sand. The reef became exposed on the eastern side of the Cape (stockpile site), on a large platform on the northern part of the Cape and a small area south-west of the power-house. The deeper water adjoining these areas had similar reef which remained underwater at low tide. In a large area to the east of the Cape, a coral reef had established.The reef exposed at low tide was characterised by a rubble substrate with turfing algae and a fine sediment layer over the top of both. All three zones were subject to high, but fine, sediment loads. This was most evident in the zone exposed at low tide. As a result, the invertebrate species suite was characteristic of these conditions. Dominant invertebrate fauna were fan-worms, sea-cucumbers (~2 per m^2), sea-anemones (*Entacmaea* and *Heteractis*) and the coral *Turbinaria*. Other corals were primarily *Alveopora*, *Favia*, *Favites*, *Lobophyllia* and some *Acropora*. Total coral cover was less than 10 percent. Several molluscs were observed, including the giant clam *Tridacna maxima* and several nudibranchs. Several small Painted Crayfish *Panulirus versicolor* were seen in crevices. The seaweeds *Caulerpa* and *Codium* were evident in small patches.

The reef which remains submerged at all times had similar substrate, but the constant water allows for algal growth. This zone was characterised by high (> 70 percent) cover of *Sargassum* species up to 30 cm high. Other seaweeds included *Caulerpa*, *Codium* and *Padina*. Live coral cover was approximately 15percent and included *Acropora*, *Galaxea*, *Hydnophora*, *Lobophyllia*, *Montipora* and *Turbinaria*. Other dominant invertebrate fauna were sponges, sea-cucumbers, sea-anemones (*Entacmaea* and *Heteractis*), soft-corals and Painted Crayfish *Panulirus versicolor*.

The submerged reef with high live coral cover (~ 65 percent) was dominated by *Lobophyllia*, but also with *Acropora*, *Fungia*, *Galaxea*, *Goniastrea*, *Hydnophora*, *Montipora*, *Pectinia*, *Platygyra* and *Porites*. Sponges, sea-anemones (*Entacmaea* and *Heteractis*), soft-corals and Painted Crayfish *Panulirus versicolor* were also common.

All three zones had similar fish fauna characteristic of shallow, turbid tropical reefs. The exposed reef had a high count of both individuals (197) and species (33), which is probably indicative of the survey effort. The dominant families in all zones were cods (Serranidae), seaperch (Lutjanidae), damselfish (Pomacentridae) and spinefeet (Siganidae).

Hawksbill Turtles *Eretmochyles imbricata* were observed in this habitat. Many of the migratory wading birds recorded for the Silty Sand habitat used the exposed reef at low tide, and Silver Gulls *Larus novaehollandiae* were common during both high and low tide.

Sandy Mud

Sandy Mud was the dominant subtidal habitat, occurring in water deeper than 8 m (spring low tide) surrounding the Cape. Two regions were examined: (i) end of wharf; and (ii) middle of wharf (dredge spoil dump).

The muddy substrate at the end of the wharf had a cover of approximately 25 percent and was dominated by turbid environment specialists such as soft corals including gorgonians and sea-whips (Gorgonacea), hydroids, sponges, bryozoans, crinoids and ascidians. There were very few algae, and those that were present were very pale indicating a turbid environment. Several species of unidentified nudibranch molluscs and cushion starfish were observed. The dredge scar was very obvious with little recruitment into the scar. The middle of the wharf, on the existing spoil dump had slightly lower cover and was characterised by a similar invertebrate fauna, but included more shallow

water species such as sea-cucumbers, sea-anemones and corals (*Goniopora*, *Moseleya*, *Mycedium* and *Turbinaria*). The edge of the spoil dump had isolated bommies with considerably higher cover.

A Hawksbill Turtle *Eretmochyles imbricata* was observed near the end of the wharf, and two sea-snakes *Aipsyurus laevis* were seen some hundred metres from the end. *A. laevis* is one of the most abundant seasnakes in coral reefs of northern Australia (Cogger, 1992).

Coral Reef

The Coral Reef, south-west of the power house is a significant habitat in the region (Figure 5.6). This extensive coral reef was characterised by very high live coral cover (>80percent) comprising ~98percent *Acropora* spp. (*A. cytherea*, *A. digitifera* and *A. hyacinthus*). Other corals included favids, fungids, *Goniopora* and *Lobophyllia*.

Given that the reclamation works are occuring on the eastern side of Cape Lambert, the coral reef is on the western side and to the south, and the ocean currents tend to move east-west, it is expected that the coral reef would not be affected by the current proposal.

Rock Wall

The final marine habitat was located on the east of the Cape and was mostly an artificial habitat. The seawalls of the existing stockpiles, and a section of natural rock created a habitat which doubles in size at high tide. The Rock Wall was sub-vertical and sat directly on the Silty Sand habitat. It therefore provided a three dimensional habitat for species on the Silty Sand, but also a feeding refuge for many species at high tide.

The wall had surprisingly few encrusting organisms (other than molluscs and barnacles), probably due to the fact that it was regularly exposed. Corals included *Cyphastrea*, *Favia*, *Favites* and *Goniastrea*. Much of the encrusting fauna is dealt with in the Rocky Shore habitat discussion.

Sedimentary Shore

The Sedimentary Shore habitat was most expansive in the bay to the east of the Cape, arising from the Silty Sand habitat. There was also a section in the northern bay. This habitat is typical of sandy beaches throughout the tropics. The back of the beach is characterised by spinifex covered dunes and heath. The beach exhibited lines of flotsam, especially coral, shells and sponges. Seaward of the beach, the Silty Sand habitat becomes continuous with the Sedimantary Shore at low tide. Since the mud flats of the Sedimentary Shore are part of this habitat, the migratory bird species considered in Section 3.3.1 are relevent here.

Rocky Shore

The rest of the Cape comprised Rocky Shore habitat. It consisted of various substrates ranging from consolidated ironstone boulders to limestone and coral rubble and in places was backed up by coastal sand dunes. Mangroves *Avicennia marina* had established in two areas: (i) east of Cape on natural rocky shore; and (ii) in northern bay (Figure 5.6).

The Rocky Shore was dominated by molluscs and crustaceans. Large conglomerations of the oyster *Saccostrea cucullata* occurred over much of the area. Spiny Chitons *Acanthopleura spinosa*, limpets (Patellidae, Acmaeidae), trochids (Trochidae), turban shells (Turbinidae), planaxids (Planaxidae), nerites (Neritidae) and dog-whelks (Nassaridae) were abundant molluscs. Acorn barnacles (Balanomorpha), hermit crabs (Diogenidae) and rock crabs (Grapsidae) were common crustaceans.

This habitat is important for migratory wading birds including the Grey-tailed Tattler *Tringa brevipes*. Sixty percent of the 104 individuals (9 species) are listed under international agreements, and one further species is priority listed by CALM.

Oceanic

This habitat comprises the open ocean surrounding Cape Lambert, and includes the wharves and the exposed reef to the east (Figure 5.6). It is therefore the habitat which will be least impacted by the proposed development. This habitat essentially includes the water surface, air and wharves above the Sandy Mud habitat.

Five individuals from three species are protected under international agreements, but these would not be affected by wharf extensions.

5.12.3 Specially Protected or Threatened Marine Fauna

Protected species observed at Cape Lambert, or expected to be present which may be affected by the proposed development are listed in Table 5.10. Most of the species listed rely heavily on the mudflats and beach of the Silty Sand and Sedimentary Shore habitats and the rocks of the Rocky Shore habitat. The number of shorebirds would increase significantly over the summer months when shorebirds migrate from the northern hemisphere.

Anecdotal information indicated that the area proposed to be used for the stockpile reclamation area was used for nesting by turtles. However, the beach is considered unsuitable for turtle breeding because it has a long gentle slope making beaching difficult for the turtles and the foredunes in the area are quite steep. CALM advised that the only information it had came from its turtle tagging program, which centred on Rosemary Island and the Kimberley coast. Robe staff working in the vicinity could not recall seeing any turtles or turtle tracks on that section of beach.

5.13 LANDUSE AND TENURE

5.13.1 Project Areas

The mining and exploration leases associated with the proposal occur on what is currently Vacant Crown Land. In addition to ML248SA, Robe also have a number of Exploration Licences in close proximity to the West Angelas proposal. These are E47709 (69.5 km^2), E47797 (107.5 km^2), and E47798 (172.2 km^2).

The railway crosses vacant Crown land and pastoral leases, as well as passing through the Karijini and Millstream - Chichester National Park. The railway crosses the pastoral leases of the following stations: Mt Welcome, Coolawanya, Hamersley and Juna Downs.

Port Walcott at Cape Lambert is administered by the Department of Transport Marine Division. Port and ship loading facilities are owned and operated by Robe which is the sole user (WAPC, 1997). The operations are located on Special Lease for Mining Operations (Lease No. 3116/4623) granted under Section 116 of the Land Act and the Iron Ore (Robe River) Agreement Act. The Cape Lambert area is zoned for heavy and industrial development under the Karratha Area Development Strategy.

Table 5.10: Specially Protected (Threatened) Marine Fauna at Cape Lambert.

Species	Expected/ Observed	CAMBA	JAMBA	CALM Declared	CALM Special	CALM Priority
Loggerhead Turtle	E	n/a	n/a	+		
Leatherback Turtle	E	n/a	n/a	+		
Green Turtle	O	n/a	n/a			4
Hawksbill Turtle	O	n/a	n/a			4
Brown Booby	O	+	+			
Lesser Frigatebird	O	+	+			
Great Egret	O	+	+			
Eastern Reef Egret	O	+				
White-bellied Sea-eagle	O	+				
Grey Plover	E	+	+			
Lesser Golden Plover	E	+	+			
Ringed Plover	E	+	+			
Little Ringed Plover	E	+				
Lesser Sand Plover	E	+	+			
Greater Sand Plover	O	+	+			
Oriental Plover	E		+			
Beach Stone-curlew	O					4
Little Curlew	E	+	+			
Whimbrel	O	+	+			
Eastern Curlew	O	+	+			3
Black-tailed Godwit	E	+	+			
Bar-tailed Godwit	O	+	+			
Redshank	E	+				
Marsh Sandpiper	E	+	+			
Greenshank	E	+	+			
Common Sandpiper	O	+	+			
Grey-tailed Tattler	O	+	+			
Terek Sandpiper	E	+	+			
Ruddy Turnstone	O	+	+			
Asian Dowitcher	E	+	+			3
Red Knot	E	+	+			
Great Knot	E	+	+			
Red-necked Stint	O	+	+			
Pectoral Sandpiper	E		+			
Sharp-tailed Sandpiper	E	+	+			
Curlew Sandpiper	E	+	+			
Sanderling	E	+	+			
Broad-billed Sandpiper	E	+	+			
Ruff	E	+	+			

Table 5.10: cont.

Species	Expected/ Observed	CAMBA	JAMBA	CALM Declared	CALM Special	CALM Priority
White-winged Tern	E	+	+			
Caspian Tern	O	+	+			
Common Tern	E	+	+			
Bridled Tern	E	+	+			
Little Tern	E	+	+			4
Fairy Tern	E					4
Lesser Crested Tern	E	+				
Dugong[d]	E	n/a	n/a		+	

[d] Dugong was reported by Scott Young (boat skipper) from eastern extreme of bay. It would be unlikely to be affected by developments since no seagrass habitat appears in the near vicinity.

5.13.2 Karijini National Park

Karijini National Park, formerly the Hamersley Range National Park, is an 'A' Class Reserve (A30082) covering 606,597 ha and is vested in the National Parks and Nature Conservation Authority (NPNCA). CALM is responsible for the management of the Karijini National Park under the Conservation and Land Management Act, 1984.

The Marandoo iron ore mine, managed by Hamersley Iron, is located centrally in Karijini National Park. This deposit is situated on a 48 km^2 temporary reserve excised from Karijini National Park by the Western Australian Parliament in January 1991. A one kilometre wide infrastructure corridor linking Marandoo to the eastern and western boundaries of the Park was also excised by Parliament in 1991. This corridor is a Section 5(g) reserve under the Conservation and Land Management Act 1984.

The main tourist sites within Karijini National Park (e.g. Hancock Gorge, Hamersley Gorge and Fortescue Falls) are located approximately 30 km north of the Hamersley Iron Central Pilbara Railway corridor.

CALM has published a Draft Management Plan for Karijini National Park which aims to assist in the management of the Aboriginal, recreational and mining interests in the Park, while protecting its conservation values. CALM's management goals for Karijini National Park are: conservation, recreation, community relations, research and monitoring and commercial use (CALM, 1995).

5.13.3 Millstream Chichester National Park

Millstream Chichester National Park is located approximately 60 km south-east of Karratha and covers an area of 199,736 ha. The Park consists of three 'A' Class Reserves (A38333, A30071 and A24392) and is managed by CALM.

A Draft Management Plan is currently in preparation for the Millstream Chichester National Park (CALM, in prep.). However, it is not yet publicly available. It is understood that it is likely that objectives for the eastern portion of the National Park will include maintenance of wilderness values. Construction of a road or railway in the eastern portion could affect wilderness values, particularly through noise impacts.

The western portion of Millstream Chichester National Park is intersected by the Dampier-Tom Price Railway and Roebourne-Wittenoom Road. Millstream - Chichester National Park is a popular tourist destination, with favoured sites including Python Pool, Snake Creek and Millstream.

5.14 POLICY AND PLANNING STRATEGIES

5.14.1 State Planning Strategy

The overall planning framework is provided by the State Planning Strategy developed by the Western Australian Planning Commission (WAPC, 1996). The document provides a strategic guide for land use planning and is a requirement of the Western Australian Planning Commission Act. 1985.

The State Planning Strategy identifies the following in relation to the West Angelas project area:

- occurs within the Pilbara minerals resource province;
- includes potential surface and ground water supply catchments along the railway alignment;
- the Karijini and Millstream Chichester National Park is identified as strategic terrestrial environmental areas; and
- Cape Lambert occurs within the North West Shelf petroleum resource province.

The focus for the Pilbara region is documented as being mineral extraction, petroleum and natural gas production and downstream processing industries. The Strategy also highlights the importance of the development of transport infrastructure to ensure internationally competitive exports.

With the exception of the Strategy's discouragement of fly in/fly out operations, the West Angelas Project is consistent with the objectives of the State Planning Strategy and Robe will ensure that the issues of water supply and the environmental significance of the National Park are incorporated into the environmental management strategy for the project.

As stated in Section 3.2.7 (Workforce) above, fly in/fly out is now the best option for mining operations because of the current fringe benefit taxation arrangements, because it avoids upfront capital costs associated with building a townsite and associated infrastructure and because it can be responsive to changing workforce number requirements. Unless these impediments can be resolved, fly in/fly out is expected to remain the most economic and preferred option of the mining industry.

5.14.2 Pilbara Land Use Strategy

The Pilbara Land Use Strategy was developed in order to minimise future land use conflict, predominantly arising from the impact of Native Title, and from competition between economic development pressures and environmental values (Pilbara Development Commission, 1997).

The Strategy provides a number of objectives and strategies relating to industrial development, mining, tourism, the pastoral industry, fishing and aquaculture, land tenure, urban development, infrastructure, heritage and culture, and environment and conservation, in addition to objectives for key regions.

The objective relating to Mining and Petroleum states:

> Recognise the national and international importance of Pilbara mineral resources, especially petroleum and iron ore resources, and the consequent need to allocate a high priority to their protection and timely exploitation.

The environment and conservation objective is to protect the important environmental resources of the Pilbara. The Karijini National Park and Central Hamersley Range are indicated in this respect and specific objectives are provided for these areas.

A component of the strategy for Karijini National Park is to develop a protocol for mining projects and associated infrastructure in order to minimise adverse impacts on the Park. Minimisation of service corridors for iron ore projects is an objective within the central Hamersley Range area. Potential for a townsite within the central Hamersley Range area is highlighted as a possibility in order to provide services for tourism and mining developments in the region.

Investigations are recommended in the central Hamersley range area in order to assess groundwater resources, safe yields and monitoring requirements to avoid potential conflict between mine dewatering and other uses of water resources.

5.14.3 Pilbara Regional Transport Strategy

The Pilbara Regional Transport Strategy (Department of Transport, 1997) states that the increased iron ore mining in the Central Hamersley Range and east of Karijini will require a series of new road and rail extensions to connect new mining operations to the existing network. The Strategy discusses the potential for sharing infrastructure between new resource developments in reference to the potential for a Central Pilbara Railway.

The Regional Transport Strategy also refers to a possible townsite location, east of Karijini National Park to service the new iron ore mining operations within the Central Hamersley region. The townsite may include land for an airport.

5.14.4 Karratha Area Development Strategy

The Karratha Area Development Strategy prepared by the WAPC (1997) is currently in draft form and is proposed for eventual conversion to a statutory region scheme. The Karratha area covers the coast between Cape Preston and Cape Lambert, stretching inland 30 km from the Karratha town boundary and offshore to the State territorial waters. The port operations therefore fall within the planning boundaries of the Karratha Area.

The primary purpose of the study is to provide a link between State, regional and local planning which is based on a balance of economic, social, cultural and environmental considerations. It has been prepared as a sub-regional development strategy in order to resolve conflicting land and water use demands, to guide and control the use of land and water, and to coordinate infrastructure provision and urban expansion for the next 25 years (WAPC, 1997).

The strategy supports the continuation of natural resource industries, as well as the retention and expansion of existing industrial sites. The towns of Karratha and Wickham are identified as the sites for future urban expansion and development. The Cape Lambert area is designated as an Existing and Potential Industrial area.

The strategy notes that sharing of rail infrastructure is to be pursued wherever possible, but recognises that railways are generally leased and subject to State Agreement Acts, and, as the railways have originally been developed for sole users sharing rail lines is constrained by train schedules, capacity limitations and legal issues.

5.15 SOCIAL AND CULTURAL ENVIRONMENT

5.15.1 Aboriginal Sites and Heritage

A number of Aboriginal site investigations have been completed in the vicinity of the proposed railway corridor and one survey covered large parts of the railway alignment when first proposed (Palmer, 1978b, 1979a). Other surveys have been conducted on, or near, the alignment (Palmer, 1977, 1978a, 1980a&b; Mulvaney 1984; Quartermaine, 1991b, 1992, 1995).

Palmer (1978b, 1979a) surveyed an alignment for the West Angelas Project which is on, or near to, the present alignment from a point near Four Corners Bore (8 km north of the Nanutarra - Wittenoom Road) to the West Angelas Project Area. Deviations are from near Packsaddle Camp to West Angelas camp. This survey work resulted in a large number of archaeological sites being recorded near the alignment. Previously, he surveyed an area for the West Angelas area which resulted in several archaeological sites being discovered (Palmer, 1977, 1978b).

Palmer (1980a&b) looked at mining leases in the area between Marandoo and the Nanaturra - Wittenoom Road and recorded a number of sites near the alignment.

Mulvaney (1994) surveyed a corridor for the proposed Tom Price North Road which co-incides with the rail alignment between the Mount Bruce Road and the Tom Price Borefield Access Road and recorded sites near the alignment. Quatermaine (1989) completed further work on this project.

Quartermaine (1991, 1992a&b, 1995, 1996) conducted survey work for the Marandoo and Marandoo - Yandi rail alignments, as well as exploration leases on Juna Downs, for Hamersley Iron. These are near the present alignment from the Nanutarra - Wittenoom Road to a point about 10 kilometres east of the Juna Downs homestead. Several archaeological sites were recorded.

To speed up the approvals process for the Marandoo Project, the State Government applied for a section 18 application under the WA Aboriginal Heritage Act, 1972-1980 for the development area in 1991, for a corridor between the Nanutarra - Wittenoom Road and the Juna Downs - Yampire Gorge Road. This was conditional to further archaeological survey work being undertaken to sample the wider corridor. This was completed by the Department of Aboriginal sites in early 1992. No report for this kind of work, or location plans for sites recorded, has been submitted to Hamersley Iron. An ethnographic survey, based on the work area clearance model, was undertaken at the same time (KAC, 1991).

As well, special legislation was enacted to exclude the area from coverage by the State Aboriginal heritage by enactment of the Aboriginal Heritage (Marandoo) Act, 1992. This resulted in a number of archaeological sites losing the protection of the original legislation.

As a result of research by the Heritage and Culture Division, it was established that 62 archaeological sites have been registered within one kilometre of the alignment. Of these sites, 26 are now removed from heritage protection.

Research indicates 23 of the remaining sites are more than 250 m from the alignment while a further 13 are 250 m or closer to the alignment.

Following a research project for the alternative rail alignments for the West Angelas Project (Quatermaine, 1997a, 1997b), a period of field work was undertaken to check parts of the alignment not previously surveyed and to identify registered archaeological sites near the alignment. The field survey involved helicopter inspection of the northern section where ground access was difficult and vehicular and pedestrian inspection of other parts of the rail alignment.

As a result of this survey, seven newly recorded archaeological sites were identified near the alignment and nine registered archaeological sites proximate to the alignment were also checked.

The location of these sites are given below:

Field Site 1	50 metres west of alignment (506 . 7658)
Field Site 2	50 metres east of alignment (508 . 7649)
Field Site 3	50 metres east of alignment (508 . 7649)
Field Site 4	50 metres east of alignment (508 . 7649
Field Site 5	150 metres south of alignment (518 . 7629)
Field Site 6	200 metres west of alignment (506 . 7657)
P4701	250 metres east of alignment (589 . 7529)
P4700	on alignment (589 . 7525)
P7011	50 metres south of alignment (652 . 7469)
P4419-P4422	not on alignment (200 metre corridor checked)
Field Site 7	150 metres east of alignment (667 . 7465)
P4418	50 metres north of alignment (675 . 746)
P4409	100 metres east of alignment (677 . 7443)

Ethnographic Sites

The first survey for ethnnographic Aboriginal sites within the West Angelas project area, and a large part of the current railway alignment, was conducted by K. Palmer in 1979. This survey involved taking an Aboriginal 'countryman' over the proposed impact areas and discussions with Aboriginal leaders in both Onslow and Yandeearra. The conclusions from this survey was that no sites would be impacted by either the West Angelas mine or the rail route (Palmer, 1979b).

In 1993, R. O'Connor undertook preliminary talks with Aboriginal elders with cultural links to the West Angelas area, specifically from the Pandjima (Bunjima) linguistic group. This consultation process established communication links between Robe and the Aboriginal elders associated with Robe's holdings in the West Angelas region (O'Connor, 1993).

B. Machin conducted an ethnographic survey of the West Angelas project area in June 1994. The purpose of this survey was to identify sites of ethnographic significance to living Aboriginal people within the boundaries of these leases. One ethnographic site of Aboriginal significance, a cave, was identified approximately 4 km east of the eastern side of Deposit A (Machin, 1994). This cave would not be impacted upon by mining activities at West Angelas. No sacred, religious or mythological sites were identified.

Following a desktop investigation of recorded ethnographic sites within the proposed West Angelas railway route (O'Connor, 1997a), ethnographic surveys were completed between July and October 1997 of the proposed West Angelas railway route and proposed gas and water pipeline routes to the West Angelas minesite (O'Connor, 1997c).

Large sections of the proposed railway passed through corridors which have already been cleared in the course of previous anthropological work, so ethnographic surveys were designed to concentrate mainly on those sections not previously examined. However, Robe also wished relevant Aboriginal people to be consulted in regard to areas previously examined, and invited groups as a courtesy measure to participate in an inspection of the proposed route.

As a result of the ethnographic survey, it has been established that there are no areas of Aboriginal significance in the path of the proposed railway, gas pipeline and water pipeline routes (O'Connor, 1997c).

In regard to ethnographic surveys conducted near the project area, Robe Exploration Leases E47/797 and E47/798 (located to the east of the West Angelas project area) were surveyed in 1997, with the finding that both leases did not contain any areas of Aboriginal significance (O'Connor, 1997b).

Robe is committed to consulting Aboriginal communities and elders as part of the planning process for any exploration or mining activities being considered in the West Angelas area.

Native title

O'Connor (1997a) lists four Native Title claimant groups which were consulted during the ethnographic survey. These are:

- Ngaluma/Injibandi (Ngarluma/Injiparnti);
- Bunjima-Niapaili-Inawonga;
- Nganawongka Wadjari; and
- Gorawarrah Mininindrah.

Other groups with interests in and around the area include:

- Kuruma (Guruma); and
- Youngaleena Bunjima.

5.15.2 Non-indigenous Heritage

The Pilbara region was first settled in the 1860s with a primary focus on the pastoral industry. Pearling developed as a significant industry from 1870s, with commercial fishing for oysters and wet-line fishing becoming important activities between 1900 - 1960. From the 1960s on, resource industries based on iron ore, gas and petroleum production have dominated the Pilbara's economic and demographic development.

There are many heritage sites throughout the Pilbara, including historic homesteads and buildings, pastoral stockyards, grave sites, remains of early industry operations, ship wrecks and campsites (WAPC, 1997).

Information on European heritage sites which could be affected was sought from the Heritage Council of Western Australia, Shires of Ashburton, Roebourne and East Pilbara, and the National Trust.

Table 5.11 lists European heritage sites near the proposed railway alignments and minesite area.

Table 5.11: European heritage sites in the vicinity of the railway and minesite

Source	Site Name	Notes
Municipal Heritage Inventory, Shire of Roebourne (Site 22)	Hicks Gap	Significant impact from Georges River route option
Municipal Heritage Inventory, Shire of Roebourne (Site 46)	Springs Station	Not affected
Shire of Ashburton	Hamersley Station	Existing railway duplicated at this location. No buildings affected.
National Trust Lonely Graves listing	Mt Herbert	An Afghan camel driver is buried half way up the steep and rugged ascent from Python Pool to Mt Herbert. Site marked by a wooden cross. Not affected

5.15.3 Demography

The Pilbara Region had a population of 42,960 in 1995, which represents 2.48 percent of the State's total population. The region's population has been and is in decline, a trend which is expected to continue until at least 2001 (Pilbara Development Commission, 1996).

The townsite of Wickham was established to accommodate the workforce for the Robe River Iron Associates facilities at Cape Lambert and provides service industries, accommodation, shopping and sporting facilities for residents. Wickham currently has approximately 2000 residents, with potential for expansion to accommodate 6000 people. Residents currently use Point Samson and Cossack for recreational purposes (WAPC, 1997).

Karratha is located 50 km south-west of Wickham and provides supplementary commercial and retail outlets, secondary and tertiary education, health and other government facilities, and airport facilities for the region.

PART THREE

ENVIRONMENTAL IMPACTS AND MANAGEMENT

6.0 BIOPHYSICAL IMPACTS AND MANAGEMENT

6.1 INTRODUCTION

The environmental factors relating to the biophysical environment have been developed by the Environmental Protection Authority based upon experience of similar projects in similar physical environments. In addition, the Guidelines which detail the factors, environmental objectives and work required have been subject to comment by involved Government agencies and were also released for a 14 day public review period.

This chapter discusses each environmental factor as it applies to the mining, railway or port component of the overall proposal. Each factor includes reference to the Environmental Protection Authority environmental objective, the policy and technical framework which applies to that factor, the environmental impacts and management of the proposal and concludes with a summary of management proposed to achieve the Environmental Protection Authority environmental objective.

6.2 VEGETATION COMMUNITIES

EPA Objective: Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.

Policy and technical framework

The State and Federal Government has endorsed National Strategy for Conservation of Australia's Biological Diversity and the National Strategy for Ecologically Sustainable Development which require the protection and preservation of biological diversity. In particular one of the core Ecologically Sustainable Development objectives is to "..protect biological diversity and maintain essential ecological processes and life support systems."

Environmental impacts and management of the proposal

The West Angelas project will require the clearing of land for pit areas, the construction of the mining associated infrastructure (e.g. waste dumps, tailings dam, access roads, village and mine site buildings), the railway corridor and the expansion of the ore processing facilities at Cape Lambert. This clearing will result in the loss of vegetation and a corresponding area of faunal habitat. Management of these impacts for the West Angelas area for linear utilities such as pipelines, roads and tracks, and for the railway are discussed below.

6.2.1 West Angelas Mine area

The total area of clearing required for camps and associated infrastructure is approximately 600 ha. Deposits A and B require clearing of approximately 2113 ha. The broadscale vegetation associations covering these two deposits are *Acacia aneura* (Mulga) low woodland and *Eucalyptus leucopholia* low woodlnad over *Triodia* hummock grassland.

Robe has in place a number of management measures for the Pannawonica minesite to minimise environmental impacts on vegetation which will also be applied to the West Angelas Mine area (Robe, 1992). These management measures include or relate to:

- identification of environmentally/ecologically sensitive areas (eg. creekline vegetation, or vegetation identified of moderate to high conservation value);
- the use of clearly visible survey markings combined with verbal instructions to all relevant personnel to minimise and contain clearing operations;

- stripping and stockpiling of top soil;
- pre-treatment, such as ripping, of areas to be rehabilitated;
- rehabilitation occurs progressively as soon as possible after cleared areas (e.g. roads, powerline construction access tracks) are no longer needed.
- quantitative monitoring of vegetation regrowth until it displays self sustaining ecological succession; and
- areas displaying inadequate regrowth receive remedial work.

Where gravel is required and it is available adjacent to works it will be reclaimed from shallow borrow pits which will be rehabilitated when no longer required. More extensive borrow pits will be rehabilitated by contouring the sides of the pit to more closely resemble local ground slopes. Topsoil and plant debris will be returned to the floor and slopes of the pit which will be ripped on the contour to promote regrowth of vegetation.

Results of rehabilitation works and trials at Pannawonica are reported in annual and triennial reports prepared under the provisions of the Iron Ore (Robe River) Agreement Act, 1964 (as amended). Visual inspections of rehabilitation works associated with the Mesa J project indicate that rehabilitation is progressing well (Streamtec, 1997b). A measure of success of the rehabilitation is the awarding to Robe of a 1997 Certificate of Merit for Environmental Excellence by the Department of Minerals and Energy.

Robe, in association with the Australian Mineral Industries Research Association is sponsoring a Spinifex re-establishment research program which is being undertaken by Curtin University, and Robe has initiated a Stored Seed Viability Trial research project which is also being undertaken by Curtin University (Streamtec, 1997b).

Robe has a Weed Management Program in place for the Pannawonica operations. A similar program will be developed for West Angelas having regard for the information provided by the flora and vegetation surveys.

There is some uncertainty about whether *Salsola kali*, is a weed or native species in the Pilbara (Hussey et.al. 1997). For the purposes of weed management, it is considered a native species.

Weeds recorded in the flora surveys include **Bidens bipinnata*, **Malvastrum americanum*, **Achyranthes aspera* and **Sonchus oleraceus*.

One of the most serious weeds is **Bidens bipinnata*, which can reduce the populations of some native annual flora species but does not have a great impact on vegetation structure.

Buffel grass (**Cenchrus ciliaris*) can seriously degrade the loamy banks of creeks and rivers in the Hamersley Ranges but does not generally extend away from this habitat into drier habitats with thinner soils. It could also invade moister mulga sites. If Buffel grass were introduced, it would be very difficult to control as it would be difficult to detect until it had sizeable populations, by which time a seed bank would have been established, making eradication virtually impossible.

Ruby Dock (**Rumex acetosa*) invades a wider habitat range than Buffel grass, in some of the habitats it invades it has a serious impact on the lower stratum of the vegetation, especially loamy sites lower in the landscape. In drier areas it has less impact but, would still displace populations of annual flora species. As it is quite visually prominent, even in low numbers, control and eradication of this weed is more practical but, would have to be carried out before populations became large to be practical.

Species which are not spread by general mining operations (i.e. from the movement of vehicles and earthmoving equipment), such as the Indian Water Fern *Ceratoperis thallictroides*, would not be considered to be within the scope of Robe's Weed Management Program.

It is proposed that only the minimum amount of overburden will be stored outside the pit area, thus

minimising disturbance to existing vegetation, with the overburden backfilled into mined-out areas where practicable and to ensure coverage above the prevailing water table within the mine pit.

6.2.2 Linear utilities (pipelines, powerlines, roads and tracks)

Direct impacts will be minimised by applying the environmental management procedures which are proposed to be used at West Angelas (see above).

Potential indirect impacts include the introduction of weeds, alteration of drainage patterns and an increase in the frequency of fire in the study area.

Weed management along linear utilities would be covered by Robe's proposed Weed Management Program.

Impacts on the vegetation and flora from the alteration of drainage result from the making of tracks which change stream and sheet flow patterns. Generally the impact when streams are crossed is very localised. However, when tracks are made across gentle slopes which have Mulga (*Acacia aneura* and related taxa) stands on them the impact can be significant. In this situation, tracks can capture the sheet flow of water across the slopes directing it into flowlines rather than allowing some to infiltrate into the slopes. This results in lowered infiltration and the death of the Mulga, which is shallow rooted. When the Mulga dies much of the associated flora species is also lost due to changes in the habitat. The potential for this to happen is significant because of the proportion of gentle slopes with Mulga stands in the area. This impact can be limited by careful selection of the layout of the tracks.

Fire management will primarily focus on restricting public access along Robe's private roads and maintenance tracks, and ensuring personnel do not undertake activities which could result in fires.

6.2.3 Borefield

Vegetation at the borefield will not be affected by drawdown because the water table is at least 50 m below the surface. Only a very small area will be affected by direct impacts for clearing of bore sites. These will not be located where there is vegetation of moderate to high conservation value. Impacts on vegetation associated with access tracks, pipeline and powerlines to service the borefield are addressed above.

6.2.4 Railway

In areas of little permanent water, terrestrial vegetation is dependent on stored moisture in soils which are replenished by ephemeral flows and surface water run-off/sheet flows from relatively large catchments. Extensive mulga *Acacia aneura*/ spinifex associations occur in the flats between the Hamersley Range and the Fortescue River. Through the Karijini National Park south-east to the West Angelas deposit the vegetation grades into low continuous mulga/ Coolabah (*Eucalyptus victrix*) woodlands along most of the major creeks and broad drainage areas.

The vegetation of the region has adapted to the unpredictable flow regime, however substantial changes to surface water flows resulting in either an increase of surface water (e.g. due to ponding above roads) or a reduction (e.g. in surface water flow "shadows" due to inappropriate placing of culverts) can seriously impact on the vegetation. The importance of surface water to stands of Mulga and Coolabah woodlands in the Mount Bruce Flats, adjacent to the existing Hamersley Iron Marandoo rail line, has been previously highlighted (O'Brien & Associates, 1992).

Mulga has roots which are adapted to taking water from thin surface soils as they have no tap roots for absorbing groundwater. They have adaptations which concentrate soil water near the plant and which conserve water within the plant. Consequently, the distribution and abundance of mulga is primarily influenced by soil moisture and pattern of surface drainage.

Mulga can be impacted by impedance or diversion of surface drainage. The loss of mulga conversely results in increased soil erosion and downstream flood levels due to the extent of moisture retention which is achieved in mulga groves.

Impacts on mulga will be minimised by utilising the drainage management measures shown in Figure 6.2

Robe has in place a number of management measures for the Pannawonica to Cape Lambert railway to minimise environmental impacts on vegetation which will also be applied to the West Angelas to Cape Lambert railway. These management measures include:

- fire prevention, reporting and procedures to follow in the event of a fire. Each locomotive and grinding machine carries at least two fire extinguishers, and each welding operation carries a fire extinguisher. Rail grinding is not undertaken on days of extreme fire danger, and a full time watch is kept behind the grinding machine for fires;
- railway access roads are to be built to the minimum safe width, incidental areas disturbed during construction are rehabilitated promptly following construction, floodways and culverts are used when necessary to minimise or rectify changes to the natural surface drainage, and access roads no longer required are rehabilitated;
- borrow pits are constructed rectangular in shape with the long axis parallel to any nearby public access roads;
- vegetation and top soil is stripped from borrow pits and access tracks and used for subsequent rehabilitation. Borrow pits rehabilitation includes battering borrow pit walls (to match the existing terrain or to a maximum slope of 1 in 3), ripping along the contour, respreading topsoil, monitoring and (if necessary) remedial seeding; and • regular weed monitoring and control is undertaken.

Robe has a sound track record of fire prevention. In 28 years of railway operation only one fire was not rapidly extinguished. Most rail grinding operations occur in the cooler months, particularly for straight sections of track which only need to be grinded once every five to six years. In total 80-100 twelve hour grinding shifts is sufficient to keep the Pannawonica to Port Lambert track operational.

As rail equipment is replaced Robe will ensure that it collects grinding dust and incorporates spark control.

Robe also assists the Department of Conservation and Land Management in its fire control operations.

Summary of management proposed

The vegetation and flora survey maps and results will be used to assist in locating facilities to minimise impacts on vegetation of moderate to high conservation significance.

Existing procedures for vegetation protection along the railway and at Pannawonica minesite will be applied to the West Angelas Project, including preparation of a Weed Management Program which will address Robe's facilities associated with the West Angelas Project.

6.3 DECLARED RARE AND PRIORITY FLORA

EPA Objective: Protect Declared Rare and Priority Flora consistent with the provisions of the Wildlife Conservation Act 1950.

Policy and technical framework

The policy framework is set by the Wildlife Conservation Act 1950, under which flora species are assessed for the extent of their occurrence, and this is described in detail in Section 5.9.

The flora surveys commissioned by Robe have added significantly to the existing knowledge or the status of flora species and a number of species of conservation interest have been identified.

Environmental impacts and management of the proposal

Direct impacts from clearing operations, or indirect impacts such as changes to drainage patterns are the two potential impacts to be considered. Both have been largely addressed in Section 6.2. However, measures in accordance with the Wildlife Conservation Act 1950 may be necessary if Declared Rare Flora and Priority Flora need to be cleared.

It should be noted that along the railway alignments the flora survey covered a two kilometre wide corridor as the exact alignment of the railway has not been determined. Many of the species of conservation interest will not be affected by the alignment because it will only affect a strip about 50 m wide. Placement of the railway within the corridor will depend on consideration of both engineering and environmental factors, such as the location of sensitive areas.

In addition to the statutory requirements, Robe will endeavour to avoid species of conservation interest by using information from the 1997 surveys, including the location of particular species and habitat identified as potentially having species of conservation interest (e.g. the cracking clay habitat in the West Angelas Mine survey area). If existing survey information is not sufficiently accurate to ensure species of conservation interest will not be affected re-surveying of areas just prior to design will be undertaken. Measures to limit the extent of vegetation clearing (e.g. marking clearing limits) will also ensure species of conservation interest are protected.

Propagation of species of conservation interest and the incorporation of these species into revegetation programmes will also be considered to further reduce impact.

Summary of management proposed

Existing management procedures for vegetation management will be applied utilising the flora survey results to avoid species of conservation interest. Consistent with existing vegetation management procedures, areas will be re-surveyed if information from the 1997 surveys does not provide sufficient information about the location of species of conservation interest.

Robe will comply with the requirements of the Wildlife Conservation Act 1950.

6.4 TERRESTRIAL FAUNA

EPA Objective: Maintain the abundance, species diversity and geographic distribution of terrestrial fauna.

Policy and technical framework

The State and Federal Government endorsed National Strategy for Conservation of Australia's Biological Diversity and the National Strategy for Ecologically Sustainable Development require the protection and preservation of biological diversity. In particular one of the core Ecologically Sustainable Development objectives is to "...protect biological diversity and maintain essential ecological processes and life support systems."

Environmental impacts and management of the proposal

All fauna impacts associated with Cape Lambert expansion are addressed under Section 6.6 Marine Flora and Fauna including specially protected (threatened) fauna.

The principal impact on fauna arising from the development of the West Angelas Project will be the loss and degradation of fauna habitat through the clearing of native vegetation. Clearing will occur in the Mine Area for mine construction, waste dumps, processing and blending infrastructure, workshops, offices, roads, railway and borrow pits. Habitat degradation has the potential to occur through factors associated with the mining process or increased human activity in the area. These include dust, introduced weed and feral fauna species, ground water changes, and changed fire regimes. The initial impact from habitat loss will be immediate on non-mobile poorly dispersing fauna unable to move from the area.

Faunal impacts have the potential to occur through a number of other factors such as introduced feral species, disturbance by noise or vibrations, weeds and road and rail deaths. Fauna movement may be restricted, in particular by the railway, but also by mining structures and infrastructure.

Significant habitats to be impacted by the West Angelas Project include Mulga Woodland and Cracking Clay.

Table 6.1 details impacts from the West Angelas Project and describes the effects and significance to fauna of those impacts.

Management

Control of clearing activities - Areas of native vegetation to be cleared will be kept to a minimum at all times to reduce the impact on fauna communities. Clearing will be conducted in stages in order to allow for the local migration of mobile fauna species into adjacent habitats. Habitats of particular local ecological significance such as Mulga Woodland and Cracking Clay habitats will be avoided wherever possible. Clearing boundaries will be well defined in the field and personnel will be educated as to the importance of adhering to these limits thus minimising disturbance to existing vegetation. Fragmentation of habitat will be minimised where possible, and can be achieved by grouping mine structures or aligning roads and other infrastructure next to existing faunal barriers.

Rehabilitation - The primary management strategy involved in addressing the large scale clearing of native vegetation and fauna habitats in the West Angelas project area will be an ongoing rehabilitation Programme. The aim of the programme will be to rehabilitate disturbed areas to an array of vegetation types and fauna habitats that reflect the pre-disturbance state as closely as possible in order to create a stable long-term environment.

Feral fauna control - The local abundance of feral fauna within the mine area is likely to increase as a result of the West Angelas development, in particular populations of House Mice and Feral Cats, which usually increase near areas of human habitation and activity. There is little that can be done to completely eradicate populations of these feral animals, however, hygienic storage and disposal of foodstuffs will help to maintain populations of these species at a minimum. An attempt will be made to reduce feral cats observed within the Mine Area by trapping near often frequented areas such as rubbish tips and camps. If ongoing monitoring demonstrates that populations of feral fauna have increased dramatically, then control measures will be considered. This may include baiting or direct culling as required. No project staff will be permitted to bring pets into the West Angelas project area.

Open pits and holes - Uncapped drill holes can pose a serious threat to small animal communities. All drill holes outside of areas which will be significantly impacted will be temporarily capped on completion of drilling and permanently capped as soon as possible. Drill holes will be regularly monitored to ensure the cap remains in place. Mine pits and tailings dams can also entrap larger

mobile animals. The boundaries of pits will be fenced or bunded to deter larger animals such as kangaroos from gaining access.

Table 6.1: Impacts and their effects and significance to fauna.

Impact	Effect (Nature of Impact)	Intensity (High, Medium, Low)	Duration (Short < 1yr, medium 1-5yr, long > 5yr)	Scale (Immediate <500m, Local < 2km, Regional < 200km)	Significance (High, Medium, Low)
Clearing	1. Loss of fauna habitat, food and shelter resources	Medium	long-term	Local	Low - Medium
	2. Death of non-mobile fauna	High	short-term	Local	Low
	3. Reduced abundance of local fauna	Low	medium-term	Local	Low
Feral Fauna	4. Predation on native fauna	High	long-term	Immediate, Local	Low
	5. Competition with and potential displacement of native fauna,	Low	long-term	Immediate, Local	Low
Noise	6. Disturbance to fauna activity patterns	High	short-term	Immediate, Local	Low
Vibration	7. Disturbance to fauna activity patterns	Medium	short-term	Immediate, Local	Low
Road/ Train Deaths	8. Death or injury to individual fauna	High	long-term	Immediate, Local	Low
	9. Changes to fauna populations	Low	long-term	Local	Low
Pollutants	10. Contamination of habitat	High	short to long term depending on the nature and toxicity of the pollutant	Immediate	Low
Fire	11. vegetation/ habitat changes	High	medium to long-term	Local/ Regional	Low to High

Summary of management proposed

Borrow pits will have slopes to permit safe passage of animals Areas to be cleared will be demarcated to minimise habitat impact by restricting clearing activities to proposed development areas, as per existing Robe policy.

Ensure that vegetation clearance, both for mine areas and infrastructure, is stage based so that areas are not cleared unnecessarily. This is expected to occur as a matter of course.

Progressive rehabilitation to occur as soon as practicable following mining or other disturbance as per existing Robe policy, with the aim of re-creating fauna habitat.

Hygienic storage and disposal of foodstuffs to discourage feral populations from increasing locally (see Section 9.3 of this ERMP)

Capping drill holes and bunding or fencing pits and tailings dams to prevent accidental fauna deaths.

6.5 SPECIALLY PROTECTED (THREATENED) TERRESTRIAL FAUNA

EPA Objective: Protect Specially Protected (Threatened) Fauna consistent with the provisions of the Wildlife Conservation Act 1950.

Policy and technical framework

Specially protected terrestrial fauna occurring at Cape Lambert (e.g. migratory shorebirds) and the policy frameworks relevant to those species are considered under the Section 6.6 Marine Flora and Fauna (including Specially Protected (threatened) Marine Fauna..

The policy framework for this environmental factor is provided by the Wildlife Conservation Act 1950 and Endangered Species Act 1992.

Environmental impacts and management of the proposal

Two protected rare fauna species are considered to be potentially impacted by West Angelas Project and requiring specific management:

1. Schedule 1 species the Grey Honeyeater *Conopophila whitei*. This species has been recorded in Mulga habitat in the Mine Area and Coondewanna West Rail Corridor in previous surveys (Integrated Environmental Services, 1978; Start & van Leeuwen, unpub.). Impact to habitat in the Mine Area will be unavoidable due to location of ore deposits. Appropriate mangement centers on:

    - Minimising impact on Mulga habitat, in particular dense Mulga in Coondawanna Flats area.

2. The Ghost Bat *Macroderma gigas* is listed as Part 2 - Vulnerable - in the Endangered Species Act 1992 and by the International Union for the Conservation of Nature (IUCN red data book,1988). The species was found roosting in caves to the north of Deposit B and maternity caves previously reported near Deposit E.

    Potential impacts include:

    - Direct destruction of caves;
    - Disturbance through human interference, noise;

- Vibrations and foraging area disruption; and
- Impalement on barbed wire.

Experience at Mesa J indicates that a 100 m barrier between mining operations and caves is sufficient to preserve caves. At West Angelas, the nearest cave is located about 500m from the nearest deposit, so direct physical impacts are expected to be insignificant. However Ghost Bat activity patterns in the area may be impacted to an unknown degree by noise and disturbance from mining activities. Barbed wire will not be used, except where there is a statutory requirement to do so.

Other protected rare species for which impacts will be neglible and for which there are no practical management measures include:

1. Schedule 1 species the Grey Falcon *Falco hypoleucos*. A pair of this species was seen within the southern section of the Coondewanna West Rail Corridor just north of the Mine Area. Impact is negligible due to large home range, so no specific management is required.

2. The Schedule 4 Peregrine Falcon *Falco peregrinus* was recorded within the Area C Project Area, 30 Km North-east of the West Angelas West Angelas Mine Area, during a recent biological survey (*ecologia*,1997). Impact negligible due to large home range, so no specific management is required.

3. The CAMBA listed species Fork-tailed Swift *Apus pacificus* occura in the Project Area. No impact is likely, so no specific management required.

Summary of management proposed

- Minimise impact to Mulga habitat, in particular dense Mulga in Coondawanna Flats area.;
- Maintain a minimum barrier which restricts access of 100 m between operations at Deposit E and the caves inhabited by Ghost Bats; and
- Barbed wire will not be used unless there is a statutory requirement to do so.

These management measures will be included in the Environmental Management Programme (refer Section 10).

6.6 MARINE FLORA AND FAUNA (INCLUDING SPECIALLY PROTECTED (THREATENED) MARINE FAUNA)

EPA Objectives Marine Flora: Maintain the ecological function, abundance, species diversity and geographic distribution of marine flora, including mangroves.

Marine Fauna: Maintain the abundance, species diversity and geographic distribution of marine fauna.

Specially Protected (Threatened) Marine Fauna: Protect Specially Protected (Threatened) Marine Fauna consistent with the provisions of the Wildlife Conservation Act 1950.

Policy and technical framework

The EPA's objective partly provides the policy framework.

The EPA is currently developing a policy on mangrove protection.

There are two policy frameworks which provide special protection to the fauna of Cape Lambert.

Firstly, there are international agreements. Two agreements have been established: China-Australia Migratory Bird Agreement (CAMBA) and Japan-Australia Migratory Bird Agreement (JAMBA). These international agreements are designed for the protection of migratory birds and birds in danger of extinction, and also for the management and protection of their environments. Under *Article IV part b. (i)* of CAMBA and *Article VI part a.* of JAMBA, Australia is required to "... prevent damage to migratory birds and their environment".

The second policy framework is the Wildlife Conservation Act 1950, which has been described above (see Section 6.3 DRF and Priority Flora and Section 6.5 Specially Protected (Threatened) Terrestrial Fauna).

In relation to the proposed dredging, the WA Marine (Sea Dumping) Act, 1991 does not specifically apply to the dredging because the spoil will be dredged from within the boundaries of a port whose waters are not part of the territorial sea of Australia which commences 12 nautical miles off the coast.

The DEP has advised that the environmental assessment process and standards identified in the ANZECC Environmental assessment of the sea disposal of dredged and excavated material (draft guidelines, 1996) would be applied to the dredging. The Draft guidelines specify a phased approach to environmental assessment and provide guidelines for sediment quality to ensure impacts on fauna are acceptable.

Environmental impacts and management of the proposal

Environmental impacts on marine flora and fauna may arise from the wharf extension, dredging of the berthing areas and disposal of spoil material, and from the creation and operation of the stockpile areas.

All impacts associated with the dredging operation are considered under this environmental factor.

Impacts from the wharf extension are expected to be minor as the structure is constructed on piles embedded in the Sandy Mud Habitat.

The dredging will result in the loss of Sandy Mud Habitat. The berthing areas will be designed to be as narrow and as short as is feasible for the tonnage and manoeuvrability of the ore ships.

Spoil disposal will take place on former spoil disposal grounds (see Figure 3.8). Spoil disposal on Spoil Dump 1 will be minimised or managed so that turbidity from disposal operations does not affect the nearby Shallow Rocky Reef Habitat which includes some coral species (See Section 7.6).

Dredging and spoil disposal is likely to create short-term high sediment loads in the water column. This will reduce the penetration of light in the water column (for algae, corals, *etc.*), potentially smothering sessile creatures and inhibiting the respiratory and feeding function of many invertebrates.

Dredging may also affect water quality due to associated lowering of dissolved oxygen levels mobilising sediment-bound contaminants and nutrients from the sediments or altering the pH of the water. All of these factors can affect marine fauna.

A dredging management plan will be prepared which considers impacts such as turbitity and the application of the draft guidelines for environmental assessment of the sea disposal of dredged and excavated material.

Table 5.2 in Section 5.13.3 lists species which are covered by the policy frameworks which provide protection to some of the fauna of Cape Lambert. Most of the species listed would rely heavily on the mudflats and beach of the Silty Sand and Sedimentary Shore habitats and the rocks of the Rocky Shore habitat. A portion of these habitats would be directly affected by construction of the stockpile

extension area (see Figure 5.6).

Consideration was given to the best location for the stockpile area. On the western side of Cape Lambert, the stockpile area would impact on a healthy stand of mangroves. On the eastern side, which is the side proposed in this ERMP, the stockpile area extension will claim Silty Sand, Rocky Shore and Sedimentary Shore habitat.

At low tide, the mudflats may become a feeding site for migratory species of shorebird, some of which are protected by International Agreements (*ecologia*, 1997). Since the marine fauna survey was not conducted during the peak season for these birds, an increase in the number of species and individuals which use the mudflats is expected in summer. At the time of the marine fauna survey, these mudflats had similar shorebird use to those east of the Cape, indicating that this area is equally important. Other mudflats are common in the vicinity and are well used by migratory species (*ecologia*, 1997).

The stockpile area extension will result in the removal of 10 to 12 small mangrove trees.

Reclamation works to construct the stockpile area have the potential to create high sediment loads. This can be minimised by constructing the external wall of the area to be reclaimed first and then filling in behind it. The external wall would be constructed of clean waste rock to reduce erosion and initial turbidity levels, consistent with the design indicated in Figure 3.6 (Section 3.4.2 Bulk earthworks). This design is adequate to cater for 1:50 year wave and surge conditions and was accepted as satisfactory for clearance of a Works Approval condition for construction of the Cape Lambert Stockpile Revetment by the DEP in 1992 .

Robe has existing management procedures to address concerns regarding the potential for waste materials (e.g scrap metals and oil) and chemical spills to affect marine flora and fauna (Refer Section 7.6).

Summary of management proposed

Robe make the following environmental management commitments:

- The proponent will construct the stockpile extension area by constructing the external wall first using clean waste rock and then backfilling behind the wall to minimise turbidity generation and impacts on marine flora and fauna (DEP).
- The proponent will prepare and implement a dredging management plan which ensures impacts on marine flora and fauna are minimised (DEP). Existing dredge spoil dumps will be utilised for dredge spoil.

6.7 WATERCOURSES

EPA Objective: Maintain the integrity, functions and environmental values of drainage systems.

Policy and technical framework

Watercourses are considered to be wetlands under the wetland definition adopted by the Western Australian Government in its Wetlands Conservation Policy for Western Australia policy document (Government of Western Australia, 1997). The wetland definition is that used in the Ramsar Convention on Wetlands of International Importance, to which Australia is signatory. The definition of a wetland is; "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

The strategies identified in the Wetlands Conservation Policy for Western Australia apply to those

areas more traditionally regarded as wetlands, including lakes, swamps, marshes, springs, damplands, impoundments, intertidal flats and mangroves. Specific conservation needs for rivers, estuaries and shallow marine areas are to be addressed through other government programs.

The EPA's Guidelines for Environment and Planning (EPA, 1997) provides management advice for watercourses and rivers. The EPA's Guidelines do not provide a specific buffer width which appears to be applicable to the conditions encountered for this proposal, but it does provide a list of factors which should be considered in determining an appropriate buffer width from watercourses and rivers.

Environmental impacts and management of the proposal

The EPA's guidelines seek an assessment of the potential impacts on surface water flow rates, drainage patterns, sediment transport and wetlands, as a result of mining activities and railway construction. Sediment transport and other potential pollution-related impacts are considered in Section 7.5 Surface Water Quality.

There are no watercourses at Cape Lambert.

Mining activities

The major impact from mining activities will be the diversion of watercourses which currently flow across proposed mine pits and stockpile areas at West Angelas.

The West Angelas valley is drained by an eastern tributary of Turee Creek. Between Deposits A and B there are three main drainage systems north, central and southern, which rise in the east and flow to the west where they form into a single system near the southern end of the proposed airstrip.

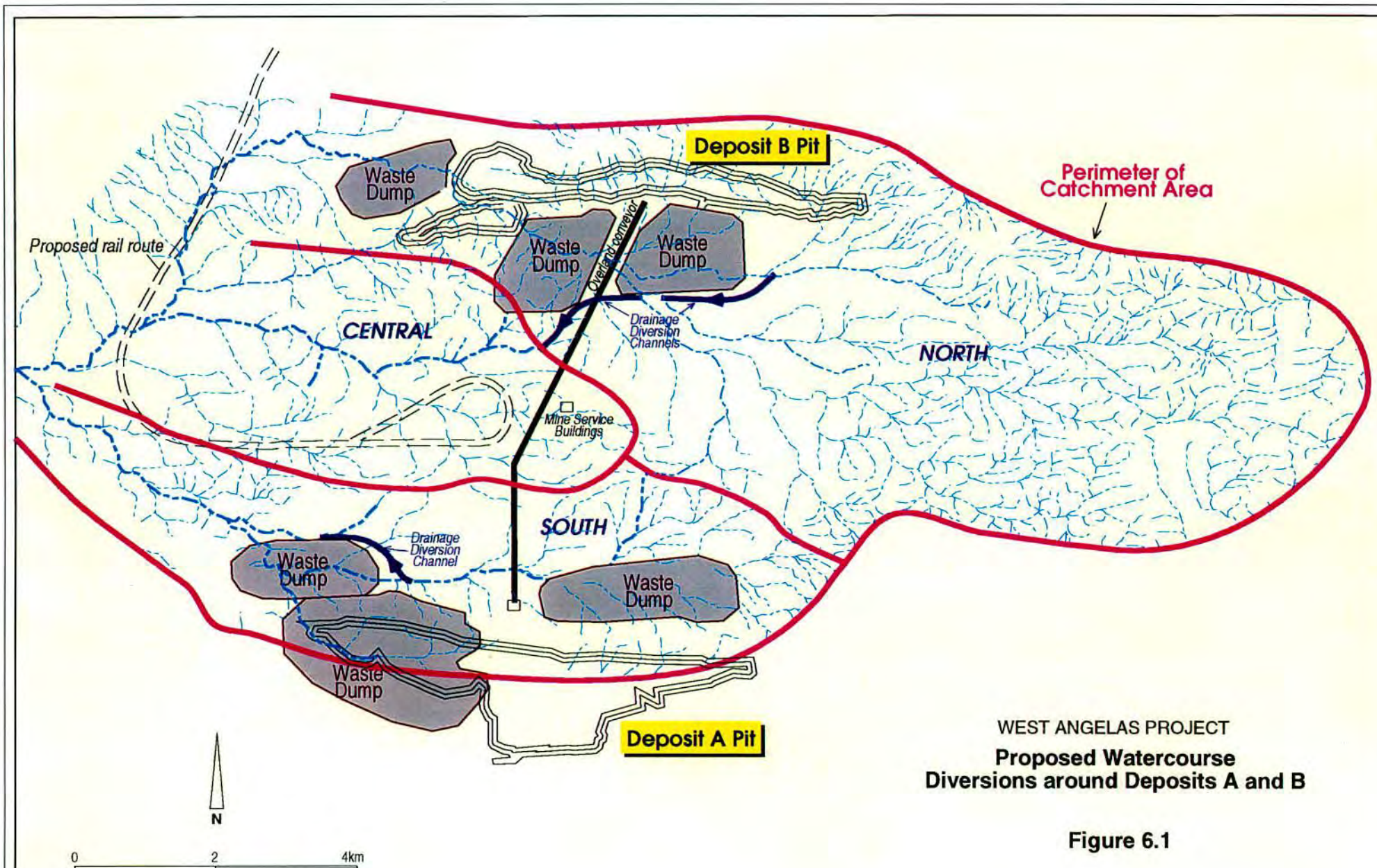
It is proposed to divert watercourses around Deposits A and B as shown in Figure 6.1, and diversions of differing significance will also be necessary around most of the other deposits.

The southern drainage system flows across the northern side of Deposit A but will eventually be isolated when the waste dumps from pit A are developed. As mining of Deposit A progresses the eastern half of the pit area will be surrounded by a draining catchment of approximately seven square kilometres. Storm water draining from this area will flow into Pit A from where it will be removed by pumping. Storm water pumped from Pit A will be collected in a suitably sized settling pond constructed to the north east of Deposit A where silt will be collected to prevent pollution of watercourses.

The northern drainage system flows across the southern side of Deposit B then cuts through the deposit near its west end. Proposed waste dumps on the southern side of Pit B will prevent the northern drainage system functioning. Storm water will be diverted from the northern system into the central drainage system by means of a channel of adequate size to carry the predicted flows.

The railroad which cuts across both the northern and central drainage systems will have drainage culverts designed to adequately dispose of all storm water including that which has been diverted from the northern to the central system.

The central drainage system at its west end flows across Deposit G which will eventually be mined. When this occurs storm drainage from the central system will be diverted into the southern branch of the central system by means of a constructed channel sized to carry the total flow, including that diverted from the northern drainage system.



WEST ANGELAS PROJECT

Proposed Watercourse Diversions around Deposits A and B

Figure 6.1

Drainage diversion management plans will be prepared prior to commencement of mining-related earthworks for each Deposit. The Drainage diversion management plans will consider the potential for erosion from changes to creek flow volumes, the need for monitoring of turbidity, erosion and associated downstream sediment deposition and construction criteria for drainage channels to minimise suspension of sediment and erosion.

Localised areas of accelerated and increased surface water flow rates may result from the creation of impervious areas such as roads and buildings. Run-off from slopes and ridges, overburden dumps, and borrow pits will be intercepted and diverted to natural drainage lines downstream of the project area. These localised changes are not expected to be significant.

Consistent with operations at Pannawonica, when dumps are located near drainage channels, the dumps will be monitored and rock armoured if necessary to prevent scouring and erosion (Robe, 1992).

De-watering water will be used totally on-site for dust management and, if feasible, for use in ore processing. There will be no de-watering water discharged into natural drainage lines, so surface water flow rates will not change as a result of de-watering activities. However, dewatering discharge into drainage lines may occur for short periods after cyclones

Railway and roads

The railway has the potential to affect surface water flow rates both in defined streams and rivers and sheet flow which characterises mulga communities.

As previously noted, mulga communities are important in the Pilbara and can be adversely affected when sheetflows are cut off. Sheetflow to sensitive vegetation will be maintained by installing multiple culverts with sill drains (see Figure 6.2). Through the use of contour dispersion channels, run-off water is redistributed as sheet flow downstream of the railway embankment.

The management of surface water flows in defined streams and rivers can be dealt with quantitatively so that with appropriate design and location of culverts and bridges to allow the conveyance of both flood events and seasonal flows, the impact is expected to be minimal.

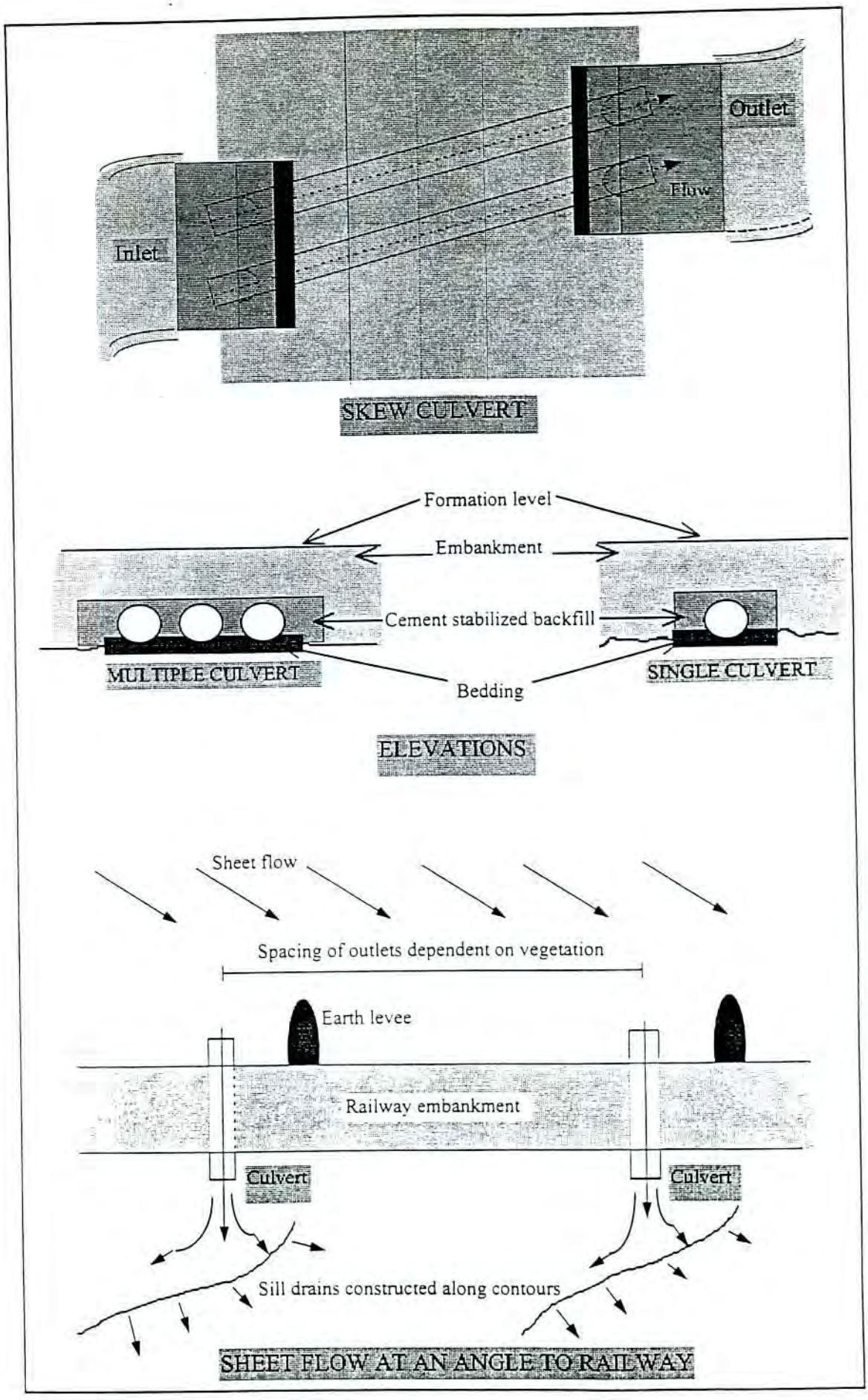
Where the railway line runs close to and parallel to Hamersley Iron's railway, Robe will, as a minimum, duplicate the existing size and type of drainage structure.

Where the railway is not close to Hamersley Iron's Railway, drainage works will consist of combinations of the following techniques:

1. Major drainage crossings: (> fourth order)
    - (i) Open span bridge
    - (ii) Multiple culverts
    - (iii) Floodways
2. Minor drainage crossings (first to third order channels):
    - (i) Single & multiple culverts
    - (ii) Skew culverts/angle crossings
    - (iii) Floodways

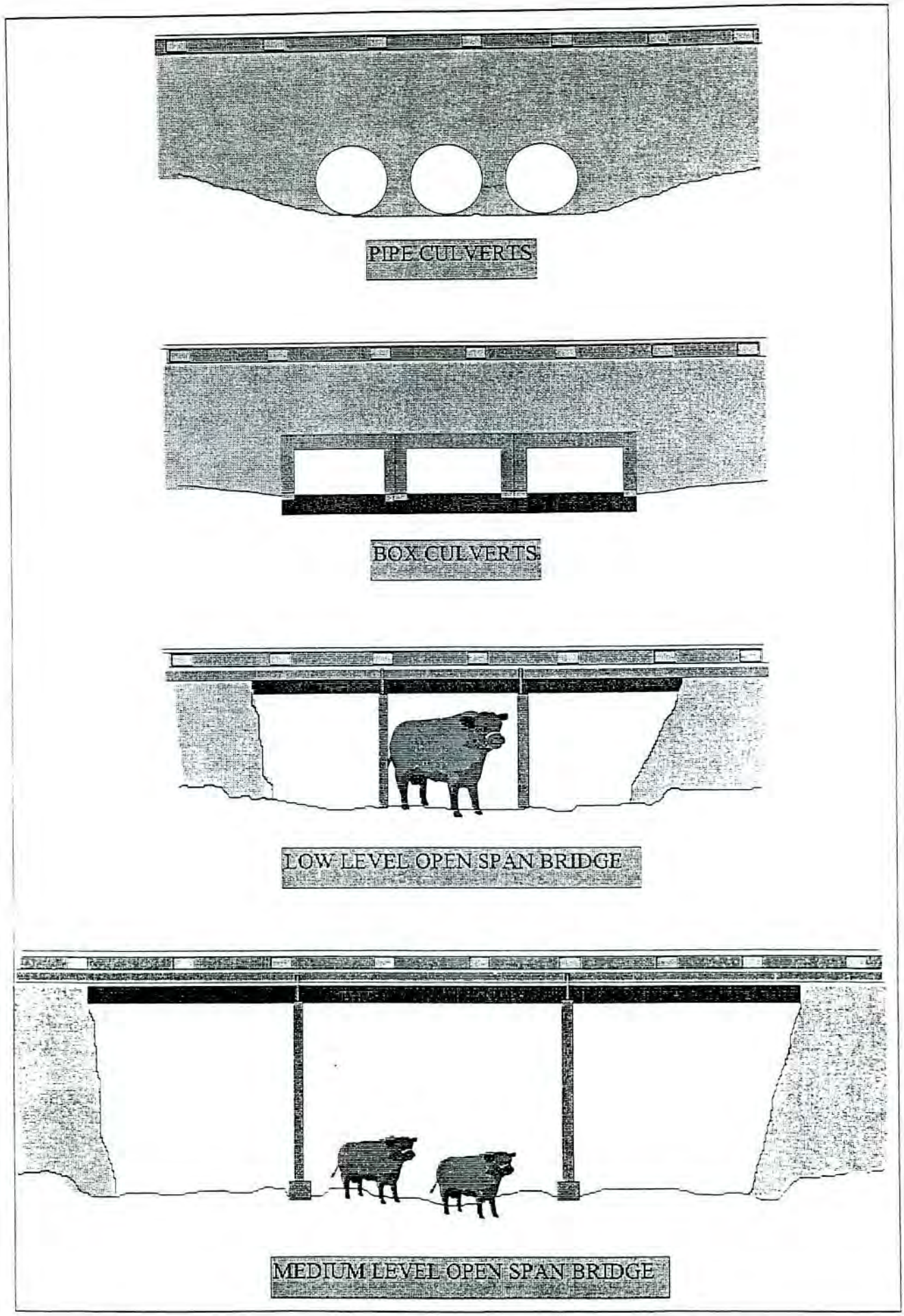
Examples of culverts and bridges and of culvert layouts are depicted in Figure 6.3.

Culverts will be designed and constructed to protect the railroad embankment and to prevent local scouring and erosion of the stream bed.



Diagrammatic representations of culvert layouts (after O'Brien 1992).

Figure 6.2



Diagrammatic representations of culverts and bridges (after O'Brien 1992).

Figure 6.3

The railroad drainage structures will generally be designed to permit the passage of a one in 20 year return interval storm with a minimum of interference to the drainage system. A one in 50 return interval storm will be used for bridges and larger culvert crossings. This is in keeping with the design storm flows adopted by other Pilbara railroads. Any requirement to increase the storm drainage provision to a one in 100 years storm return interval would result in drainage structure requirements to at least double in size and capacity, increasing the area affected by the railway alignment, the landscape impacts and the cost by 50 to 75percent.

The probability of a one in 100 year structure being required during the estimated 25 year life of the West Angelas project is very low. Evidence over the past 25 years along the Robe and Hamersley railroads suggest it is unlikely that a one in 50 year return period storm event has been experienced.

At each watercourse crossing, parameters of flow, stream and embankment gradients, stream bed material and riparian vegetation must be assessed. These parameters, in combination with catchment areas and run-off calculations, can then be used to determine the most appropriate culvert/bridge construction. Constriction of flow through too small diameter culverts can result in increased water velocities and increased scour and bank erosion. The natural direction of flow should also remain unchanged. The design of the culverts and bridges will minimise flow "shadows" and upstream ponding.

Roads will include a combination of culverts and floodways to accommodate high volumes of surface run-off following significant rainfall events.

Railway and road alignments will avoid fringing vegetation (e.g. *Eucalyptus camaldulensis*) along watercourses.

Summary of management proposed

Robe make the following environmental management commitments:

- Drainage Diversion Management Plans will be prepared prior to commencement of mining-related earthworks for each Deposit. The Drainage Diversion Management Plans will consider factors such as the potential impacts of increased flow volumes and management measures to minimise erosion in existing channels, and design and construction criteria for drainage channels to minimise sediment suspension and erosion.

- Where the railway alignment parallels existing railways, Robe will as a minimum duplicate the existing standard (i.e. size and capacity) and type of drainage structure.

  Where the railway is not parallel to an existing alignment, Robe will determine the size and type of drainage structure based on catchment size with a one in 20 or one in 50 Average Recurrence Interval for storm events, stream and embankment gradients, stream bed material and riparian vegetation to ensure minimal scouring or change of stream direction.

6.8 GROUNDWATER

EPA Objective: Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.

Policy and technical framework

The Water and Rivers Commission (WRC) has responsibility for issuing groundwater extraction licences and ensuring that such licences take into account environmental impacts.

The Pilbara Iron Ore Environmental Committee is currently developing a policy on mining below the water table.

Environmental impacts and management of the proposal

Water requirements for the West Angelas project are estimated to be between six and 16 ML per day. The Turee Creek (B) borefield site, some 35 km west of the mine and downstream of Karijini National Park is expected to be able to supply around 8-9 ML/d, and further investigations are taking place to the west of Turee Creek (B). Vegetation at the Turee Creek (B) borefield is unlikely to be affected because the groundwater is at least 40-50 m below the surface.

The most significant effect of the Turee Creek (B) borefield development is likely to be on regional groundwater levels. A drawdown of 50 m may develop at the bore. However, the drawdown is likely to be very small or negligible beyond a distance of three to five kilometres from the bores, but after 30 years of groundwater abstraction small drawdowns may extend into Karijini National Park (Woodward-Clyde, 1997). The small drawdown is unlikely to affect any groundwater dependent vegetation which may occur in the gorges of the area.

However, a monitoring program which includes a vegetation survey of the gorges of Karijini National Park to the immediate north of the borefield will be prepared to assess the potential impact of long term groundwater abstraction, and liaison with CALM will take place to determine management strategies if impacts on vegetation are identified.

A total 12-15percent of the Deposit A ore body is below the water table. However, due to the relatively impermeable nature of the geological strata, the volume of de-watering required is expected to be low and all dewatering will be processed and used on-site with no drainage into existing channels. As it is expected that dewatering volumes will be low, dewatering will be undertaken using sump pumps with minor (if any) abstraction by dewatering bores. There will be no discharge to the environment as water will be used for dust control and process water.

It is proposed to back-fill the pit so the groundwater table is below the surface so that losses of groundwater through capilliary action and subsequent evaporation will be negligible following completion of mining.

Summary of management proposed

The requirements of groundwater abstraction licences issued by the WRC will be complied with.

Robe make the following environmental management commitment:

- An Groundwater Extraction Management Plan to monitor regional groundwater drawdown and which includes monitoring to detect groundwater impacts in the vicinity of the gorges in Karijini National Park which may experience groundwater drawdown, will be developed (WRC & CALM).

6.9 LANDFORM

EPA Objective: Establish stable, sustainable landform consistent with surroundings.

Policy and technical framework

The objective specified above partly sets the policy framework for this proposal.

The DME Guidelines for Mining in Arid Environments (Department of Minerals and Energy, 1996) specify minimum technical criteria that should be met in mining landform construction which take into account the potential for erosion and progressive revegetation and rehabilitation of overburden waste dump sites.

Environmental impacts and management of the proposal

Overburden will be stored in waste dumps constructed alongside each open pit, covering an area of 938 and 380 ha respectively for Deposits A and B. These waste dumps will be constructed and rehabilitated in accordance with the Guidelines for Mining in Arid Environments (Department of Minerals and Energy, 1996). The Guidelines cover a wide range of matters including ideal profiles for waste dumps in the context of surrounding landform, likelihood of erosion and revegetation of the dumps. Consistent with operations at Pannawonica, dumps will be designed to present a low and stable profile to the wind (Robe, 1992).

The decommissioned mining pits will remain inconsistent with the surrounding landform, but will not be visible from any tourist locations.

Summary of management proposed

Overburden will be stored and rehabilitated consistent with the Department of Minerals and Energy (DME) Guidelines for Mining in Arid Environments (DME, 1996).

7.0 POLLUTION MANAGEMENT

7.1 PARTICULATES

EPA Objective: Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards.

7.1.1 Dust

Policy and technical framework

DEP licence conditions cover dust generation at the existing operations at Cape Lambert and the Pannawonica minesite.

The EPA Guidelines for dust are 1000 $\mu g/m^3$ for 15 minute ground level concentrations, and 90 $\mu g/m^3$ in residential areas (EPA, 1992). For 24 hour and annual average concentrations PM_{10} values of 120 and 40 $\mu g/m^3$ apply in residential area (EPA, 1997).

Environmental impacts of the proposal

Dust generation will result throughout the mining process. This includes blasting, ore extraction, crushing and transport. Dust control is a necessary component of occupational health and safety and these control measures are also expected to reduce off-site dust movement.

Dust control measures such as watering by truck-mounted sprays will be utilised on unsealed regularly trafficked roads. Dust generation will be further minimised by limited clearing and prompt rehabilitation of disturbed areas (Robe, 1992)

Where scrubbers are used within the process plant, the slurry produced will be pumped to a settling dam, with water recovered and returned to the scrubbers.

Experience has shown that dust from rail haulage is not a problem.

The nearest residential area to Cape Lambert is over two and a half kilometres to the south east, the nearest residential area to the railway line is Wickham which is about one kilometre away, and the nearest residential area to the mine will be the camp, located about eight kilometres from the mine. Therefore, with normal management practices in place dust impacts on residential areas is not an environmental concern.

Nevertheless Robe are currently reviewing impacts and monitoring requirements for dust entering the environment at Cape Lambert (North, 1997).

Summary of management proposed

Dust generation is regulated by the DEP's Works Approval and Licensing process. Robe will ensure all Works Approval and Licence conditions are met.

Robe will review impacts and monitoring requirements for dust entering the environment at Cape Lambert consistent with the needs identified in North's Environment Health and Safety Annual Report 1997.

7.1.2 Asbestos

Asbestos in the form of crocidolite is known to occur within two principal zones in the Marra Mamba Iron Formation, the Marra Mamba Riebeckite zone (the lowermost) and the Viveash Riebeckite zone. Anecdotal evidence suggests that in the south-eastern part of the Hamersley Province, the most common occurrence of crocidolite is in the Viveash Riebeckite zone at approximately two to three metres below the top of the McLeod Member. As a consequence, the Viveash Riebeckite zone is of major importance, as iron enrichment may extend into, or close to, this zone. Mining may therefore encroach upon this horizon, with the possibility of encountering asbestos being greatest when developing the footwall to final pit limits.

Policy and technical framework

The Department of Minerals and Energy has produced Asbestos Management in Mining (Department of Minerals and Energy, undated) which defines the problem (i.e. types of asbestos and associated health risks), details occupational health standards and recommends a number of strategies which can be used to manage asbestos. The Australian occupational health standards are recognised as the most stringent in the world.

It is well established that health risks can arise from the inhalation of airborne asbestos fibres and consequently health and safety issues are associated with project development. However, it should be noted that the consensus opinion by scientific evidence is that the theory that one asbestos fibre can kill cannot be supported. Asbestos is widespread in the environment and normal, healthy lungs contain a significant loading of fibres: in a 70 year old lung there are up to one million fibres per gram of lung tissue (Berry et al, 1989 in Department of Minerals and Energy, undated)

Environmental impacts and management of the proposal

Mine

Crocidolite has been intersected in foot wall drill holes and minor occurrences are likely to occur during mining.

The control strategies in the DME guideline on management of asbestos in mining will form the basis of the program for the West Angelas project. Site specific strategies are detailed below:

Drilling

All drilling will be carried out with water injection in order to suppress dust generation. A commercial dust collection system will be fitted to all blast hole drill rigs, with the operator to work from an air conditioned and sealed cabin, with make-up air passing through appropriate filters.

Mapping

Drill chips from holes drilled on each bench in high risk areas will be logged and bench faces mapped during excavation. If asbestos minerals could possibly be encountered, or are found, the area will be designated as a hazardous area containing fibrous minerals. Dust masks and other protective equipment will be worn by all people entering the designated area. Control measures such as wetting down dust generation areas and access to the site limited to sealed equipment, will be enforced. A standard training program will be provided for all personnel required to enter a hazardous area. Disposable coveralls will be worn by all personnel required to work in a non-air conditioned location within a hazardous area.

Blasting

The area will be wetted down after blasting to minimise dust generation. Personnel will be restricted

from entering the area after blasting until sufficient time has elapsed to let the dust settle.

Excavation

Operators will work from within sealed equipment. All materials identified as containing asbestos will be mined to a special stockpile area located in the centre of the waste dump and will be promptly encapsulated with other waste material to prevent dust generation. On completion of mining in a contaminated area, all equipment will be washed down.

Occurrence in the final pit wall

Where small exposures of asbestos minerals are located in the final pit wall, the occurrence will be sealed *insitu* by the use of epoxy-based paint. Where it occurs on a larger scale, asbestos will be sealed *insitu* by shotcreting the surface (i.e. covering the surface with cement) or other appropriate means.

Additional procedures include:

- contractors will undertake to comply with all Statutory Regulations relating to exposure of the workforce to hazardous fibres;
- workforce induction will include identification and procedures for handling the material; and
- the project manager will carry out frequent audit checks to ensure that procedures are being adhered to.

It is expected that implementation of these procedures will ensure asbestos fibres are not a hazard when the mine is decommissioned.

Railway

The procedures identified in above will also be used during construction of the railway.

Summary of management proposed

Robe will comply with the recommended practices described in the Department of Minerals and Energy Asbestos Management in Mining publication and Section 7.1.2 of the ERMP.

The procedures identified in Section 7.1.2 of the ERMP will also be used during construction of the railway.

7.2 GREENHOUSE GASES

EPA Objective: Ensure that greenhouse gas emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act, 1986 (all reasonable and practicable measures are taken to minimise greenhouse gas discharge).

Policy and technical framework

Greenhouse gases produced by human activities include carbon dioxide, methane, nitrous oxide, ozone, chorofluorocarbons (CFCs), hydrochorofluorocarbons (HCFCs) and perfluorocarbons. An increase in greenhouse gases due to human activities is believed to be responsible for causing increases in the earth's temperature.

Australia is signatory to the Framework Convention on Climate Change which has the goal of stabilising Australia's Greenhouse Gas emissions at 1990 levels by the year 2000.

The EPA has prepared a Draft Policy on Greenhouse Gas emissions for stakeholder consultation which identifies the EPA's requirements for environmental impact assessment of greenhouse gas emissions (EPA, 1997). The policy requires the ERMP to:

- estimate the amount of greenhouse gases that may be emitted from the proposed project during its life cycle;
- indicate the intended measures to be adopted to minimise total greenhouse gas emissions in the proposed project;
- compare the greenhouse gas efficiency of the project with other similar projects; and
- indicate if the project will be entered into the Commonwealth Government's "Greenhouse Challenge" voluntary cooperative agreement program.

The EPA's policy also specifies matters to be addressed in a subsequent Environmental Management Plan including an accurate determination of greenhouse gas emissions and the final measures to be adopted. A recent decision by the Western Australian Minister for the Environment required a draft Environmental Management Plan on Gaseous Emissions concerning Greenhouse Gasses to be made publicly available for a four week period. The EPA intends that the DEP's licensing conditions require annual monitoring and reporting.

Environmental impacts and management of the proposal

Robe currently releases greenhouse gases, predominantly carbon dioxide from energy generation by:

- electricity production from natural gas fired boiler;
- use of diesel fuelled locomotives; and
- use of trucks/excavators and other machinery.

Based on 12 Mt/a of ore production the following estimates were prepared, using information obtained for existing operations:

- estimated electricty usage would be between 60-120 GWh per annum, generating between 49-87kt per annum of CO_2;
- diesel use for locomotives would generate about 54 kt per annum of CO_2 emisions; and
- trucks and excavators would generate about 15 kt per annum of CO_2 emissions.

The total CO_2 gas emissions for the project, based on 12 Mt of ore and data from existing operations, would be expected to be between 118 and 156 kt CO_2 per annum.

Robe have prepared a draft Action Plan for the Greenhouse Challenge Program (North Limited, 1997). The Action Plan was developed for the existing operations at Cape Lambert and Pannawonica and took into account the proposed development at West Angelas. Robe is therefore familiar with the sources of greenhouse gas emissions and options to reduce greenhouse gas emissions. Table 6.2 summarises sources and management proposals to be implemented between 1997 and 2002 which have been quantified in the Action Plan.

Table 6.2: Sources and management proposals for Greenhouse gas emissions from Robe's operations, including the West Angelas project.

Source (s)	Action(s)	Outcome	Emission Reduction (tonnes of CO_2)	percent of 2000/1 Emissions
Road and rail transport of ore	Use of fuel additives in trucks and locomotives to reduce fuel consumption and have cleaner emissions	Fuel consumption reduced 4percent	3 450	1.7percent
	Improvements in material handling efficiency by decreasing rock size	Fuel saving of 2.5percent	1 012	0.5percent
	West Angelas Project Utilisation of lighter ore cars	Reduced fuel needs and cars can carry more tonnes of ore each	4 119	1.0percent
	West Angelas Project Selection of new locomotives	Higher efficiency units saving power consumption	10 798	5.3percent
Rock screening operations	Upgrade secondary screens to increase operating efficiency	Five percent increase in operating efficiency	59	0.03percent
Under investigation				
Ore transport to train	Undertake detailed review of conveyers vs trucks for ore transport to rail head at Pannawonica minesite	Greater energy use but 14percent reduction in greenhouse gasses.	1 511	0.7percent
Power station operations	Upgrade the Cape Lambert Power Station in cooperation with Western Power & Alinta Gas	Three percent increase in operating efficiency	2 204	1.1percent
Potential reduction in CO_2 emissions			25 153	10.33percent

In addition to the actions above Robe intends to consider the following during the life of the Action Plan:

- alternative energy sources;
- mine dewatering;
- heat integration of pellet plant if this plant re-commences production;
- energy monitoring and information system;
- purchase of new haulage trucks;
- modification of electric motors to include variable speed drives;
- purchasing policy and capital projects; and
- energy awareness and waste minimisation training.

Summary of management proposed

Robe will implement the actions proposed in the Greenhouse Challenge Program document prepared by the company.

Robe makes the following environmental management commitment:

- Robe will prepare a Greenhouse management document prior to completion of the construction phase which addresses:
  - the accurate amount of greenhouse gases emitted from the project during its life cycle; and
  - final measure adopted to limit total project emissions.

7.3 GASEOUS EMISSIONS

7.3.1 Sulphur Dioxide

EPA Objective: Ensure that SO_2 emissions meet the air quality standards and limits stated in the Kwinana EPP and requirements of Section 51 of the Environmental Protection Act, 1986 (all reasonable and practicable measures are taken to minimise SO_2 discharge).

Policy and technical framework

The EPA's objective adequately specifies the policy and technical framework.

Environmental impacts and management of the proposal

The power station at the minesite will be powered by natural gas, which produces negligible (if any) sulphur dioxide gas. Furthermore, the power station will be located 15 km from the nearest residential area (i.e. the West Angelas camp) and will be about eight kilometres from the minesite.

The EPA's objective will be met.

Summary of management proposed

The power station will be powered by natural gas so there will be negligible (if any) sulphur dioxide emissions.

7.3.2 Nitrogen Oxides

EPA Objective Ensure that NOx emissions meet the air quality standards and limits stated in the Kwinana EPP and requirements of Section 51 of the Environmental Protection Act, 1986 (all reasonable and practicable measures are taken to minimise NOx discharge).

Policy and technical framework

The EPA has not established standards for nitrogen dioxide emissions.

The National Health and Medical Research Council have developed nitrogen dioxide standards for residential areas. The standard specifies that for a one hour averaging period, a level of 320 $\mu g/m^3$ is not to be exceeded more than once per month. The USEPA and World Health Organisation specify 150 $\mu g/m^3$ for a 24 hour average and 100 $\mu g/m^3$ for an annual average respectively.

Environmental impacts and management of the proposal

The likely ground level concentrations of nitrogen dioxide at the mining camp located eight kilometres from the power station were modelled using the HG SYSTEM series of models.

The assessment was based on the following assumptions for each gas turbine:

- a flow rate of 27 kg/s gas;
- a concentration of 250 ppm of NOx pollutant;
- ambient temperatures of 20°C;
- a stack height of 10 m and diameter of 1.5 m;
- stable weather conditions;
- a stack temperature of 400°C (allows for radiation effects); and
- a wind speed of 6 m/s, or 2.5 m/s in worst case.

Even given the worst case analysis, it was clear that the levels of NOx at the camp would be minimal. The expected levels in the worst case with the wind blowing a plume directly towards the camp would be about 160 $\mu g/m^3$ (Burns and Roe Worley, 1997).

Therefore no special management is required.

7.3.3 Other Potential Concerns

Concern was expressed about the potential for particulate emissions (VOC's) from power generation. VOC's arise from diesel fuelled power generators. However, gas turbines or gas fuelled reciprocating engines are proposed to be used for power generation and these produce negligible VOC's.

7.4 GROUNDWATER QUALITY

EPA Objective: Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the WA Guidelines for Fresh and Marine Waters (EPA, 1993).

Policy and technical framework

The WA Guidelines for Fresh and Marine Waters promote the concept of environmental values or beneficial uses. These beneficial uses set the water quality criteria which should be met in the groundwater.

In National Parks, the beneficial uses to be protected would be "protection of aquatic ecosystems". Outside of the National Parks, pastoral land use is the most common land use. Therefore, the "livestock and farmstead water supply" beneficial uses would apply in pastoral areas.

The WRC have recently published a Water Resources Review and Development Plan (Water and Rivers Commission, 1996) which details existing and potential groundwater resources and the proposed Priority system of surface and groundwater resource protection. The WRC is currently in the process of classifying each source into either a Priority 1, 2 or 3 source protection area (Water and Rivers Commission, 1996).

Environmental impacts and management of the proposal

Changes to groundwater quality at the mine may arise from:

- materials used in surface operations such as waste oils or from accidental spills reaching the groundwater; or
- mining operations below the water table.

The mined material in this region is oxidised, so acid-mine drainage is unlikely to be an issue.

Adequate measures will be put in place to ensure that potential groundwater contaminants are collected and disposed of appropriately. For example, oily waste collection points, consisting of a silt trap and a sump, will be placed at all heavy and light vehicle refuelling points. A pump will be used to pipe the waste from the collection point via pipelines to the containment tank. Bunded earth catchment areas will be constructed at each tank farm. An oily waste treatment plant, based on that being successfully used at Pannawonica, is proposed for the remote Deposit B lay-down area and primary crusher.

The village location at the minesite is well separated from the groundwater, so groundwater quality impacts are not expected.

As previously noted less than 15 percent of the Deposit is below the groundwater table. However, it is proposed to back-fill the pit so that the groundwater table is sufficiently below the surface so that there will not be any adverse impacts on groundwater quality. The water quality and particularly salinity of a disused mine pit below the water table is determined by a number of factors including the salinity of the groundwater, the rate of evapo-transpiration and the rate of re-charge of the water in the mine pit.

During operation of the mine any surface water which runs into the pit will be pumped out to a settlement pond and such surface water is unlikely to contain significant levels of contaminants (See Section 7.5 Surface Water Quality below).

The tailings dam will contain water which has been used to process ore. No chemicals are used in this process and minerals in the ore do not become dissolved so groundwater contamination is not a concern.

The railway passes over the Millstream public water supply aquifer so contaminants on this section of railway must be managed so as to ensure water quality specified by the raw water for drinking water supply beneficial use are met. The impacts of spillage of materials carried along the railway which could contaminate groundwater is addressed in the Surface Water Quality environmental factor below. The potential for contaminants to cause groundwater pollution from railway operations is considered to be insignificant because of the low probability of spills occurring and substantial depths to groundwater.

Existing procedures are in place at Cape Lambert to minimise the potential for contaminants to enter the environment and these are detailed in Section 7.6 (Marine water and sediment quality).

Summary of management proposed

Potential groundwater contaminants will be collected and disposed of appropriately, in accordance with existing procedures.

Robe makes the following environmental management commitment:

- Robe River Mining Pty Ltd will backfill with clean materials mining pits constructed below the watertable.

7.5 SURFACE WATER QUALITY

EPA Objective: Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).

Policy and technical framework

The policy framework for the Surface Water Quality environmental factor is the same as that applies for the Groundwater Quality environmental factor (Section 7.4 above).

The WRC have recently published a Water Resources Review and Development Plan (Water and Rivers Commission, 1996) which details existing and potential surface water resources. The WRC is currently in the process of classifying each source into either a Priority 1, 2 or 3 source protection area (Water and Rivers Commission, 1996).

Environmental impacts and management of the proposal

Changes to surface water quality from operations at the minesite or Cape Lambert may arise from:

- contaminants from materials used in surface operations such as waste oils or from accidental spills reaching the groundwater;
- erosion of constructed earthworks; or
- increased levels of turbidity resulting from localised areas of accelerated and increased surface water flow.

Surface water quality is unlikely to be affected by dewatering discharge as all water will be used on-site and is unlikely to be acidic.

Robe has in place a number of management measures at Pannawonica and Mesa J to minimise the possibility of contaminants entering the environment. These management measures include or relate to:

- design of workshop buildings to incorporate closed drainage systems routed through oil-water separators;
- fuel handling and storage;
- handling of waste oil;
- liquid effluent disposal, including washdown water etc;
- storage and use of hazardous materials (e.g Chlorine and sulphuric acid);
- collection and disposal of toxic and hazardous materials; and• procedures to be followed for fuel, oil or chemical spillages .

If there was minor contamination occurring (e.g. hydrocarbons from parking areas) it is likely that mine contaminants in the river course would be quickly diluted by storm-event discharge and any material deposited in the lower reaches would be quickly mixed and diluted with clean sediment from other parts of the catchments. Prevention of contaminants entering the environment is Robe's existing and preferred approach.

Increased levels of turbidity from earthworks such as waste dumps and mine access roads are likely to result in relatively minor environmental impacts because the Pilbara region is characterised by episodically-high river flows with high levels of turbidity, and the West Angelas minesite does not have any permanent or semi-permanent waterbodies along the watercourses. However, Robe will undertake measures which minimise the potential for erosion and the associated sediment/turbidity

levels which could result.

Surface water run-off from the mine pits and haul roads will be discharged into settlement ponds with capacity to hold a 1 in 3 year Average Recurrence Interval rainfall event (based on the maximum pit size during the minesite operations) before discharge into natural channels, as currently occurs at Pannawonica.

Drainage design from other areas such as the tailings dam and mine access roads will emphasise infiltration and retention rather than directing run-off to natural creek systems. Water sensitive designs will be used where possible, such as around buildings.

Construction of the waste dump adjacent to the mining pits will occur in accordance with Department of Minerals and Energy Guidelines to ensure that erosion and turbid run-off is minimised.

The railway passes through the Harding River Dam catchment, so surface water quality impacts must be managed so as to ensure water quality for drinking water is not affected.

The potential for an accident which results in pollution of surface waters from railway operations is considered to be neglible. However, Robe has an existing procedure in place should a spillage occur. Any spillage in the Harding River Dam catchment (between the 50 and 55 km section of the existing track) is to be reported immediately to the Adviser Environmental Affairs (Robe, 1992). There have been no fuel spillages from railway operations since the commencement of railway operations in 1972. Only ore and fuel are carted on the railway.

Robe has in place other management measures relating to railway operations to minimise the possibility of contaminants entering the environment including:

- no litter to be disposed of from trains ; and
- refuelling only to occur in designated areas fitted with internal drainage systems and oil interceptors.

There are no watercourses at Cape Lambert, and measures to prevent contaminants entering the marine environment via surface water runoff are described in Section 7.6 (Marine water and sediment quality) below.

Summary of management proposed

Waste dumps will be constructed in accordance with Department of Minerals and Energy guidelines.

Existing Robe procedures to minimise the potential for contaminants to enter the environment will be applied to the West Angelas Project.

7.6 MARINE WATER AND SEDIMENT QUALITY

EPA Objective: Maintain or improve the quality of marine water consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).

Maintain or improve marine water and sediment quality consistent with Environmental Quality Objectives (EQO's) and Environmental Quality Criteria (EQC's) defined in the Southern Metropolitan Coastal Waters Study (1996).

Policy and technical framework

The draft WA Guidelines for Fresh and Marine Waters specify water quality criteria which need to be met to protect beneficial uses/environmental values such as protection of aquatic ecosystems, recreational water quality and aesthetics, raw water for drinking supply, agricultural use and industrial

water supplies. None of the environmental values apply directly to port operations, but can be applied to nearby areas, such as areas used for fishing.

The EQO's specified in the Southern Metropolitan Coastal Waters study are detailed in Table 7.1.

Table 7.1: EQO's as described in the Southern Metropolitan Coastal Waters Study

Environmental Quality Objective		Explanation
EQO 1	Maintenance of Biodiversity	Biodiversity (i.e. the variety of all life forms, the different plants, animals and micro organisms, the genes they contain and the ecosystems they form) is protected (i.e. genetic diversity at the species level so no species becomes extinct)
EQO 2	Maintenance of Ecosystem Integrity	Ecosystem Integrity is "the ability to support and maintain a balanced, integrative, adaptive community or organisms having a species composition, diversity and functional organisation comparable to that of a natural habitat in the region) is maintained (i.e. structure (species richness) and function (e.g primary production)). This EQO has a three class system as detailed below.
EQO 2	Class I Conservation zone	This represents maximum protection of ecosystems and corresponds to the environmental quality of a natural or pristine state. Coastal waters in this class should not receive any waste discharges, nor be affected by human-made changes within the catchment or surrounds of the waterbody, or the waterbody itself.
EQO 2	Class II - Multiple Use Zone	This level of protection requires that any contaminant discharges or human made changes which do occur may be readily absorbed or withstood by the waterbody without any detectable effects on the biota or functioning of the ecosystem.
EQO 2	(Class III - Industrial buffer zone)	This represents a moderate level of protection which requires that contaminant discharges or human made changes cause neither a detectable change in the diversity of the biota, nor loss of ecological function. However, resultant changes in the abundance/biomass of the biota within this zone may occur.
EQO 3	Maintenance of Aquatic Life (including molluscs) for Human Consumption	Aquatic life will be maintained for human consumption
EQO 4	Maintenance of Recreational Values	Recreational values, particularly for direct contact recreation (i.e. swimming) are protected.
EQO 5	Maintenance of Aesthetic Values	Aesthetic values will be mainatained.

For each EQO, water and sediment quality criteria have been determined which would ensure that the objectives are met. There are no specific criteria or guidelines for navigation and shipping.

The policy framework provides for Exclusion Zones where environmental values are not protected. However the extent of these zones must be minimised and may vary in size according to which environmental value is being protected. This formal designation then provides clear guidance for regulation and management and informs the community of where, and to what extent, environmental values are not protected.

The overall concept is that all operations aim to achieve the highest EQOs and that areas where each

EQO apply be mapped.

In addition to the above there are a number of international conventions and agreements, as well as voluntary guidelines which apply to shipping and port operations, and to dredging. These include:

- Australian Quarantine and Inspection Service (AQIS) Guidelines for the management of ballast water for vessels arriving in Australia from overseas ports;
- International Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships Ballast Water and Sediment Discharge by the International Maritime Organisation's Marine Environment Protection Committee (these guidelines are based on the AQIS guidelines);
- International Safety Guide for Oil Tankers and Terminals;
- Tanker Owners' Voluntary Agreement concerning Liability for Oil Pollution;
- Federal Acts including the Environment Protection (Sea Dumping) Act, 1981 and Protection of the Sea (Prevention of Pollution from Ships Act 1983 which includes the means of controlling pollution from ships contained in the International Convention for the Prevention of Pollution from Ships (known as MARPOL 73/78) and recognises the London Dumping Convention (Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter);
- The WA Pollution of Waters by Oil and Noxious Substances Act, 1987 which ratifies the International Convention for the Prevention of Pollution from Ships (1973);
- Environmental Protection Amendment Regulations (No 2) 1991 relating to organotin (TBT) antifouling paint; and
- Shipping and Pilotage Act, 1967.

Environmental impacts and management of the proposal

Section 6.6 (Marine flora and fauna (including specially protected (threatened) marine fauna) addressed the management of all aspects of the proposed dredging.

The impacts considered under this environmental factor relate to management of potential contaminants from land operations at Cape Lambert and the potential impacts from ships using the port.

Robe has in place a number of management measures specific to Cape Lambert to minimise the possibility of contaminants entering the environment. Land-based management measures include or relate to:

- accidental spillages on land;
- waste oil, oily waste and battery acid management from the locomotive workshops;
- fuels and oil storage and dispensing;
- waste management, including management of hazardous wastes, toxic wastes, waste oils, flammable materials and chemicals, and recycling;
- closed drainage systems in areas where potentially hazardous or toxic materials are used such as the warehouse;
- build-up of oil and grease in the drainage system from general railroad activity;
- disposal of soil contaminated by hydraulic oil discharge;
- design of stormwater drainage systems so as to prevent the discharge of discoloured or otherwise contaminated waste water to sea (by infiltration, detention and solar drying;
- stormwater system failure; and

- fuel, oil or chemical spillage.

Design to ensure retention of contaminated stormwater on-site was a condition of Works Approval issued by the DEP.

Potential impacts from ships include the introduction of contaminants by accidental discharges, discharge of sewage waste, ballast waters, engine coolant waters and bilge waters, and from washdown. Tributyl tin from flaking or chemical leaching off ship hulls can also affect marine water and sediment quality.

The Cape Lambert facility is within the boundary of Port Walcott. Prime agency status for Port Walcott lies with the Department of Transport as the administrative authority of that port. Robe River Iron is a facility operator within the port. Pilotage is compulsory for all vessels greater than 150 gross tonnes.

Robe's Marine Department is responsible for ensuring that operations under its control do not cause pollution of port waters (Robe, 1992).

Shipping-related management measures already in place include or relate to:

- ballast water discharge - the Marine Department provides assistance to AQIS in its efforts to assess and minimise the risk of introducing foreign marine organisms within ballast water in accordance with the AQIS guidelines;
- bilge water discharge into the environment is prohibited. All bilge water from vessels under Robe's direct control must be pumped out at the service wharf for treatment through the oil separation plant, and any vessel visiting Cape Lambert that is observed to discharge bilge water or similar into port waters is reported to the Harbour Master;
- sewage wastes. Under the MARPOL 73/78 convention seagoing vessels are required to have sewage holding tanks which must be pumped out at sea at locations remote from coastal resources. Any vessel observed discharging sewage waste in port is to be reported to the Harbour Master;
- wastes are not allowed to leave any vessel under the control of Robe's Marine Department;
- waste oils and oily wastes must be disposed of in accordance with Robe's procedures;
- a waste management plan has been prepared, which requires separation of refuse at source and outlines procedures for disposal of different types of waste;
- compliance with the Environmental Protection Amendment Regulations (No 2, 1991) relating to the use of organotin (TBT) antifouling paint;
- measures to minimise the quantity of paint flakes (regardless of the antifouling agent used) from line boat maintenance at John's Creek Boat Harbour;
- all fuel tankers entering the port must be subscribing members of the Tanker Owners' Voluntary Agreement concerning Liability for Oil Pollution, must have valid International Oil Pollution Prevention Certificates and must provide a written declaration to the Harbour Master regarding a number of criteria. A safety checklist is required to be completed and signed prior to initiation of loading and discharging, and this must occur in accordance with the International Safety Guide for Oil Tankers and Terminals.
- an Oil Spill Contingency Plan is being prepared (in consultation with Department of Transport, DEP & CALM). Robe's role would be to act as a Combat Agency and would tackle Tier 1 spills (i.e. small spills);
- cargo spill management procedures are in place which includes a requirement that cargo spilt on wharfs be recovered, not washed or swept into the ocean. The Harbour Master has

authority to take whatever action is deemed appropriate to ensure an appropriate clean-up response.

The shipping channel and berthing basins dredged by Robe do not require maintenance dredging because of scouring by tidal currents and the movement of deep draught ships. Robe's policy requires any additional dredging to be referred to the DEP.

Robe are currently undertaking sediment sampling work in order to determine the extent of the Exclusion Zone EQO area which has resulted from past port activities. This work will be reported to the EPA prior to it commencing its assessment. It is expected that the management measures already in place will have limited sediment contamination, and hence the Exclusion Zone EQO area, to that affected by tributyl tin flaking of ships hulls. The extent of the Exclusion Zone EQO area for the wharf extension is most likely to be limited to the 390 m extension and a buffer zone in which tributyl tin affects the sediment.

Summary of management proposed.

Robe River shall continue to apply the existing management measures and procedures to new operations to protect the marine environment at Cape Lambert.

8.0 SOCIAL SURROUNDINGS, IMPACT AND MANAGEMENT

8.1 ABORIGINAL CULTURE AND HERITAGE

EPA Objective: Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act (1972 - 1980).

Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area.

Policy and technical framework

The EPA objectives above specify the policy and technical framework.

Environmental impacts and management of the proposal

Section 5.16.1 (Aboriginal sites and heritage) describes the results of archeological and ethnographic surveys, and the current number of native title claimants in the project area. In summary, there are no areas of Aboriginal significance (archeological or ethnographic) in the path of the railway or minesite.

Summary of management proposed

Robe is committed to consulting with Aboriginal communities and elders as part of the planning process for any exploration or mining activities being considered in the West Angelas area.

Robe River will comply with the requirements of the Aboriginal Hertitage Act.

8.2 NON-INDIGENOUS CULTURE AND HERITAGE

EPA Objective: Comply with statutory requirements in relation to areas of cultural or historical significance.

Policy and technical framework

The statutory policy and technical framework is provide by the Federal Australian Heritage Commission Act, *Heritage Act of Western Australia, 1990* and the Town Planning and Development Act, 1928 which together provide for registers of heritage places. Under these Acts local authorities are required to compile Municipal Heritage Inventories. In addition to this community groups such as the National Trust maintain registers of significant places.

Environmental impacts and management of the proposal

As described in Section 5.16.2 (Non-indigenous heritage) above, no part of the proposal is likely to affect any heritage listed areas.

8.3 PUBLIC HEALTH AND SAFETY

EPA Objective: Ensure that risk is managed to meet the EPA's criteria for individual fatality risk off-site and the DME's requirements in respect of public safety.

Policy and technical framework

This environmental factor applies to the natural gas pipeline.

The EPA's criteria define risk to mean the likelihood of unwanted consequences, such as death, injury, damage to property or damage to the environment, from the realisation of specified hazards. A hazard is an object or situation which has the potential to cause such unwanted consequences (EPA, 1992). Risk assessment is used to assess unwanted consequences of industrial accidents, as opposed to natural hazards or continuous emissions of pollutants from industry.

The EPA criteria specify the individual fatality risk levels from new hazardous industry proposals as acceptable or not acceptable. The fatality risk is based upon an imposed or involuntary risk as opposed to a self-exposed risk. The overriding principle of the criteria is that of "avoiding avoidable risks".

The criteria specify that a risk level in residential zones of one in a million per year or less, is so small as to be acceptable to the EPA. One in a million criterion assumes that residents will be outdoor at their homes, exposed to the risk 24 hours per day and continuously day after day for the whole year, and do nothing to avoid being harmed.

Australian Standards apply to the construction and operation of gas pipelines.

The WA Petroleum Pipelines Act. 1969 applies to gas pipeline constructions.

Environmental impacts and management of the proposal

The gas pipeline does not go within one kilometre of any residential areas.

An application for a pipeline licence will be made to DME according to the *WA* Petroleum Pipelines Act. 1969. The pipeline will be designed, constructed and tested in accordance with the requirements of Australian Standard AS - 2885 1997, Pipelines - Gas and Liquid Petroleum Code. The code specifies requirements for materials, design, corrosion mitigation, welding, construction, inspection and testing, allowable operating pressure, safety precautions, risk assessment, valves and fittings and operation and maintenance.

The pipeline will be hydrostatically tested in accordance with Australian Standard AS 1978 - 1987, Pipelines - Gas and Liquid Petroleum - Field Pressure Testing. Construction welds will be subject to radiographic inspection to meet the code requirements.

The pipeline will be protected from external corrosion by an appropriate coating and cathodic protection along the length of the pipeline. The pipe joints will be coated with a compatible coating system.

The pipeline will be buried with a minimum cover of 750 mm. The position of the buried pipeline will be indicated with marker signs at frequent intervals (typically every 400 m) as well as by aerial distance markers at 10 km intervals to assist with aerial pipeline inspection. At all significant road and stream crossing, the pipe will be buried at depths not less than 1 200 mm.

Summary of management proposed

Robe make the following environmental management commitments:

- The gas pipeline will comply with Australian Standards AS -2885 - 1997 and AS 1987 - 1987, will be licensed under the Petroleum Pipelines Act, 1969 and will not be located within one kilometre of residential areas.

9.0 OTHER PROPOSAL ASPECTS WITH MULTIPLE ENVIRONMENTAL FACTORS

9.1. RAIL ROUTE

9.1.1 Rail Route Selection

The environmental factors associated with the rail route selection have been addressed in Section 2.3.2 above.

9.1.2 Multiple use of Rail Route

Concern was expressed during consultation with stakeholders in the project formulation phase that future additional rail requirements must be capable of being accommodated on the same alignment through the Millstream - Chichester National Park. Several other potential minesites occur in the east Pilbara.

The State Agreement Act requires multiple use of rail infrastructure. What is not spelt out is whether third parties will accept commercial terms. This should be left for future negotiations with third parties who may wish to access the rail. In summary use by other operators of Robe's railway is not considered to be an environmental factor as key issues revolve around matters such as cost sharing and independent control of rail operations which can be dealt with as part of Robe's State Agreement Act.

Robe will allow other mining companies to widen cuttings and fill adjacent to the existing alignment so as to utilise the existing alignment, provided there is no cost or interference to Robe's rail operations.

9.1.3 Materials for Rail Operations

As previously noted (see Section 3.3.2) track ballast and concrete aggregates will be quarried from the existing 10 KP quarry at Cape Lambert and possibly a new quarry located near Hamersley Iron's new Hill D quarry.

Robe will operate the quarries in accordance with DME Environmental Management of Quarries guidelines (DME, 1991) to minimise environmental impacts associated with quarry operation to the requirements of the Department of Minerals and Energy.

A concrete sleeper manufacturing plant will be temporarily constructed adjacent to 10 KP quarry site for a period of two years. This plant will be subject to the requirements of Part V of the Environmental Protection Act 1986.

9.2. Explosives Storage

Explosive storage will follow the guidelines currently used at Pannawonica. Explosives will be held in a secure, cyclone proof fence enclosure well removed from all mine workings, accommodation and office buildings. Ammonium nitrate will be stored on high ground out of reach of the 100 year flood level, and in accordance with the Department of Minerals and Energy requirements and explosives storage licences.

9.3 Waste disposal

Domestic waste from the permanent village and from the mine site will need to be disposed of in a purpose built landfill site. The landfill site will be selected in accordance with guidelines prepared by Geological Survey of Western Australia, (Hirschberg, 1993) and operated in accordance with the Department of Environmental Protection's Code of Practice for Country Landfills (Department of Environmental Protection, 1996a) and Landfill Waste Classifications (Department of Environmental Protection 1996b).

Wherever practical solid materials such as scrap metal will be recycled.

The Department of Environmental Protection is able to place conditions under Part V of the Environmental Protection Act on the landfill operation through placing additional conditions on the licence for operation of the mine.

Sewage wastes will be generated by the village, administration building and workshops, laydown areas, the ore processing plant area and railroad inspection building. Wherever the anticipated usage is less than ten people a standard septic system and leach drain will be provided.

Larger collections systems will consist of a package treatment plant based on the biofilter system with the treated effluent discharged into a fenced non-overflow evaporation pond.

Each sewage treatment facility will be serviced by the unit supplier on a contract basis. Treatment and disposal of wastes will be in accordance with the Health Act and requirements of the local authority.

9.4. DECOMMISSIONING

Three construction camps will be required along the length of the proposed rail alignment, each to house up to 150 people. The camps will be required for a 30 month construction period. Following completion of construction, the three rail camps will be totally removed and also most of the mining camp will be removed with the remainder retained for accommodation for contractors brought in for plant upgrades and expansions.

Consistent with operations at Pannawonica aspects of the operation decommissioned in the medium term such as plant sites and access roads will be progressively rehabilitated. All plant, buildings and other structures will be removed, the areas ripped and rehabilitation works as described under vegetation communities above completed (Robe, 1992).

9.4.1 Railway / Port Decommissioning

Clause 10(e) of the Iron Ore (Robe River) Agreement Act provides:

"...that on the cessation or determination of any lease licence granted hereunder by the State to the Company of land for the plant site or the Company's wharf for any installation within the harbour or the Company's railway or for housing at the port or port townsite the improvements and things erected on the relevant land and provided for in connection therewith other than plant and equipment shall remain or become the absolute property of the State without compensation and freed and discharge from all mortgages and encumbrances and the Company will do and execute such documents and things (including surrenders) as the State may reasonably require to give effect to this provision".

PART FOUR

ENVIRONMENTAL MANAGEMENT STRATEGIES

&

COMMITMENTS

10.0 ENVIRONMENTAL MANAGEMENT STRATEGY

10.1 INTRODUCTION

The aim of this section is to document environmental management strategies to be applied to the West Angelas Iron Ore Project proposal.

10.2 ENVIRONMENTAL MANAGEMENT SYSTEMS

10.2.1 Robe's Integrated Health, Safety and Environment System

All management systems be they ISO 14000, BS 7750, DuPont, or NOSA have the same basic components. As such, Robe will move in the same general direction as ISO 14000 and BS 7750 but follow the DuPont line and focus more on people's behaviours than paper work.

Robe also plan to integrate the Environmental Management System with the Occupational Health and Safety System. Such integrated Health Safety and Environment systems have been successfully introduced at a number of DuPont sites. Significant overlap exists between these systems in areas such as:

- chemical selection;
- dangerous good storage and handling;
- spill prevention;
- waste management (e.g. Asbestos);
- noise and dust suppression; and
- mosquito control.

This integration recognises that environmental management is everyone's responsibility.

North Limited (the majority joint venture partner in Robe River Iron Associates) has recently published its first Environment Safety and Health Annual Report (North, 1997). The Environment Safety and Health Annual Report noted:

- external reviews of all operations, including Robe, were conducted by independent consultants between January and April 1997, and the Annual Report responds to the consultants recommendations; and
- the Annual Report was prepared by a Steering Committee which included independent experts.

As a result of the review by independent consultants the following actions are proposed at Robe for Cape Lambert and general mining operations:

Land	
Rehabilitation and management	• Increase funding provision for old mine workings from $50 000 to $100 000 per year
Water	
Monitoring and impact assessment	• Review the power station cooling water environmental monitoring program
Emergency response	• Develop emergency procedures for marine oil/diesel spills in consultation with the facility operators/regulatory agencies
Air	
Monitoring and impact assessment	• Review impacts and monitoring requirements for dust entering the environment at Cape Lambert
Air quality control	• Increase the percentage of plant roads sealed from 15percent to 30percent
Materials handling and waste	
Hazardous materials and dangerous goods	• Implement a fuel management program with Mobil Oil Australia Limited • Complete development of the Chem Alert system
Monitoring/impact assessment	• Investigate the need for a ground water monitoring network around the fuel farm
Waste disposal/recycling	• Develop a PCB disposal plan
Training	
Environmental	• Conduct safety/environment induction refresher for all employees; • Conduct incident reporting training for new supervisors

Robe was certified to ISO 9002 in 1993 and has a quality management system which is externally audited.

10.2.2 Australian Minerals Industry Code for Environmental Management

In addition to the above-mentioned Environmental Management System, Robe have committed to the Australian Minerals Industry Code for Environmental Management. The Code has a strong emphasis on environmental performance accountability and community consultation, and requires signatories to report publicly on environmental performance and implementation of the Code. Signatories of the code are committed to excellence in environmental management by implementing the following principles:

- *sustainable development* by integrating economic, environmental and social considerations into decision making;
- *environmentally responsible culture* by demonstrating management commitment and appropriate staff training;
- *community partnership* by consulting the community;
- *risk management* to achieve desirable environmental outcomes;
- *integrated environmental management* by integrating environment into all operations;
- *performance targets* by setting targets not necessarily limited to legislation, licence and permit requirements;
- *continual improvement* by reviewing objectives and implementing management strategies;

- *rehabilitation and decommissioning* by taking into account beneficial uses of sites and leaving sites in a safe and stable condition; and
- *reporting* to government, the community and within the company.

10.2.3 Iron Ore (Robe River) Agreement Act

Clause 7AC of the Iron Ore (Robe River) Agreement Act details Robe's environmental obligations. These include:

- carrying out a continual programme of investigation, research and monitoring to ascertain the effectiveness of the measures it is taking both generally and pursuant to approved proposals for the protection and management of the environment;
- submission of annual reports concerning environmental protection and management measures undertaken, and details of any investigations, research and monitoring performed;
- triennial environmental reports providing more detailed discussion and analysis than contained in annual reports, and contained a programme of environmental protection and management proposed for the following three years.

North undertake mining related research through Energy Resources of Australia (ERA),and Robe is currently doing research on spinifex propagation in minesite rehabilitation and supporting a project on ecosystem re-establishment through the Australian Centre for Minesite rehabilitation research.

10.3 ENVIRONMENTAL MANAGEMENT PLAN

Robe River Iron Associates recognises that an Environmental Management Plan which details the application of existing management procedures to West Angelas and reflects existing commitments is required.

Robe makes the following environmental management commitment:

- Prior to construction, an Environmental Management Plan would be prepared which would include, but not be limited to consideration of:
  - rehabilitation and revegetation of disturbed areas;
  - drainage design along the railway at watercourse crossings and through sheet flow areas (i.e. mulga);
  - dust management;
  - implementation of Department of Minerals and Energy guidelines for Mining in Arid Environments, Asbestos Management in Mining and Environmental Management of Quarries;
  - measures to prevent contamination of ground and surface waters;
  - an overview of timing for implementation of commitments; and
  - reporting requirements (including those for the Greenhouse Challenge Program, and those noted in Section 10.2 above).

10.4 INTEGRATION OF ENVIRONMENTAL MANAGEMENT SYSTEMS AND ENVIRONMENTAL REPORTING

Each of the above voluntary environmental management systems or legal requirements requires some form of reporting.

The reporting requirements from the ERMP process will be integrated within the other annual and triennial reporting frameworks to address all environmental reporting requirements simultaneously. Audit table codes will be included in reports for ease of reference.

11.0 COMMITMENTS

This section summarises management commitments for the West Angelas project. Where subsequent approvals processes ensure adequate environmental management, they are not reproduced here.

Commitment (Who/what)	Objective (Why)	Action (How/ Where)	Timing (When)	Whose advice	Measurement/ Compliance criteria
The stockpile extension area will be built by constructing the external wall first using clean waste rock and then backfilling behind the wall.	To minimise turbidity generation and impacts on marine flora and fauna.	At Cape Lambert	Construction phase.	DEP	As above.
The proponent will prepare a dredging management plan.	To ensure impacts on marine flora and fauna are minimised.	At Cape Lambert.	Prior to commencement of dredging operations.	DEP	Dredging plan developed and implemented.
Where the railway alignment parallels existing railways, Robe will as a minimum duplicate the existing standard and type of drainage structure. Elsewhere Robe will determine the size and type of drainage structure based on catchment size with a one in 20 Average Recurrence Interval for storm events or a one in 50 Average Recurrence Interval at bridges and major culverts stream, embankment gradients, stream bed material and riparian vegetation to ensure minimal scouring or change of stream direction.	To minimise changes to watercourse hydrology.	Along the railway alignment.	Pre-construction.	WRC	Plans approved by WRC and culverts built to plans.
Drainage Diversion Management Plans will be prepared.	To minimise erosion, sediment transport and turbidity.	At each new deposit	Prior to commence-ment of mining-related earthworks for each Deposit.	WRC	Drainage diversion management plans developed and implemented.

Commitment (Who/what)	Objective (Why)	Action (How/ Where)	Timing (When)	Whose advice	Measurement/ Compliance criteria
A Groundwater Extraction Management Plan to monitor regional groundwater drawdown and which includes monitoring to detect groundwater impacts in the vicinity of the gorges in Karijini National Park which may experience groundwater drawdown, will be developed	To ensure vegetation in gorges is not adversley impacted	Around the Turee Creek (B) Borefield	Within one year of commencem ent of pumping	WRC & CALM	Reporting and actions in accordance with the Groundwater Extraction Management Plan.
A Greenhouse management document will be prepared.	To document minimisation of greenhouse gasses.	For the West Angelas Project.	Following construction .	DEP	Greenhouse Challenge Reports.
Mining pits constructed below the watertable will be backfilled with excavated materials.	To ensure no changes to groundwater quality through evaporation.	In pits mined below the water table.	During mining operations.	WRC & DEP	
The gas pipeline will comply with Australian Standards AS -2885 - 1997 and AS 1987 - 1987, will be licensed under the Petroleum Pipelines Act 1969 and will not be located within one kilometre of residential areas.	To minimise risk.	Along the pipeline.	Constructio n phase	DOME & DEP	Quality assurance reporting.
Robe River Mining Pty Ltd will allow other mining companies to widen cuttings and fill adjacent to the existing alignment in National Parks so as to utilise the existing alignment, provided there is no cost or interference to Robe's rail operations	To maintain a service corridor through National Parks.		Life of project	DRD	

Commitment (Who/what)	Objective (Why)	Action (How/ Where)	Timing (When)	Whose advice	Measurement/ Compliance criteria
An Environmental Management Plan would be prepared which would include, but not be limited to consideration of: • rehabilitation and revegetation of disturbed areas; • drainage design along the railway at watercourse crossings and through sheet flow areas (i.e. mulga); • weed management; • dust management; • implementation of Department of Minerals and Energy guidelines for Mining in Arid Environments, Asbestos Management in Mining and Environmental Management of Quarries; • measures to prevent contamination of ground and surface waters; • an overview of timing for implementation of commitments; and • reporting requirements (including those for the Greenhouse Challenge Program, and those noted in Section 10.2 above).	To ensure the environment is protected by consolidating environmental management requirements into one concise document.	Continue and update existing environmental management systems	Prior to construction	DEP	Annual and triennial reporting.

ABBREVIATIONS AND UNITS OF MEASUREMENT

(in alphabetical order)

Abbreviations		Units of measurement	
AAD	Aboriginal Affairs Department	cm	centimetres
ANZECC	Australian and New Zealand Environment and Conservation Council	DWT	Dry Weight Tonnes
CALM	Department of Conservation and Land Management	ha	hectares
CAMBA	China Australia Migratory Bird Agreement	m	metres
DEP	Department of Environmental Protection	km	kilometres
DME	Department of Minerals and Energy	km^2	square kilometres
DOLA	Department of Land Administration	ML	Megalitres, or Mining Lease
DRD	Department of Resources Development	Mt/a	Mega tonnes per annum
DRF	Declared Rare Flora	t/h	tonnes per hour
EPA	Environmental Protection Authority		
ERMP	Environmental Review and Management Program		
JAMBA	Japan Australia Migratory Bird Agreement		
NPNCA	National Parks and Nature Conservation Authority		
P1 ... P4	Priority one to Priority four		
WAM	Western Australian Museum		
WAPC	Western Australian Planning Commission		
WRC	Waters and Rivers Commission		

REFERENCES

Atkins, K.J. (1996) Declared Rare and Priority Flora List. Department of Conservation and Land Management, 21 October 1996.

Australian and New Zealand Environment and Conservation Council (1992) Australian Water Quality Guidelines for Fresh and Marine Waters. ISBN 0 642 18297 3.

Barrie Machin Tamora Pty Ltd (1994) Report on a survey for ethnographic sites in the West Angelas Area: Mining Lease 248 SA and Exploration Licence (47/709). Prepared for Robe River Mining Co. Pty. Ltd.

Beard, J.S. (1975) Pilbara Explanatory Notes to Sheet 5 1:1,000,000 Series Vegetation Survey of Western Australia. UWA Press, Nedlands.

Bettenay, E., Churchward H.M.and McArthur W.M. (1967) Atlas of Australian Soils, Sheet 6, Meekatharra-Hamersley Range area. CSIRO, Melbourne.

BHP-Utah Minerals International (Iron Ore) (1987) Yandicoogina (Marillana Project Public Environmental Report) November 1987. Unpublished Report.

Bunn S.E. & Davies P.M. (1992) Community structure and water chemistry of a salinised river system in south-western Australia. Hydrobiol. 248: 143- 160.

Bureau of Meteorology (1995) Climate of Western Australia. Bureau of Meteorology, Department of the Environment, Sport and Territories, July 1995.

Burns and Roe Worley (1977) Dispersion calculations for West Angelas Power Station - Memorandum to Paul Gower of Robe River dated 21 October 1997.

CALM (1995) Karijini National Park, Draft Management Plan 1995. Department of Conservation and Land Management, Perth.

CALM (in prep) Millstream Chichester National Park, Draft Management Plan. Department of Conservation and Land Management, Perth.

Department of Environmental Protection (1996a) Discussion Paper for Code of Practice Rural Landfill Management, November 1996

Department of Environmental Protection (1996b) Landfill Waste Classification and Waste Definitions

Department of Minerals and Energy (undated) Asbestos Management in Mining. Department of Minerals and Energy Mining Operations Division.

Department of Mines (1991) Environmental management of quarries: Development, operation, rehabilitation guidelines. Department of Minerals and Energy, March 1991.

Department of Resources Development (1996) Western Australian Iron Ore: Production to Processing. Department of Resources Development, Western Australia.

Department of Resources Development (1997) Western Australian Iron Ore Industry Review: An Overview of Iron Ore Industry Developments. March 1997, Department of Resources Development, Western Australia.

Department of Transport (1997) Pilbara Regional Transport Strategy. Department of Transport and Pilbara Development Commission, April 1997.

ecologia (1995) Yandi Stage II Biological Assessment. Unpublished Report Prepared for BHP Iron Ore Pty. Ltd.

ecologia (1996a) Hope Downs Biological Assessment. Unpublished Report Prepared for Hancock Prospecting Pty. Ltd.

ecologia (1996b) Weeli Wolli Creek Biological Assessment Survey. Unpublished Report Prepared for BHP Iron Ore Pty. Ltd.

ecologia (1997) Cape Lambert Port Facility Extensions: Marine Environmental Impact Assessment. Unpublished Report Prepared for Robe River Iron Associates, October 1997.

ecologia (1998) West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey. Unpublished Report Prepared for Robe River Iron Associates, March 1998.

Environmental Protection Authority (1988) Inland Waters of the Pilbara, Western Australia Part 1: A Report of a Field Study Carried Out in March - April 1983. Techncial Series 10, Environmental Protection Authority, Western Australia.

Environmental Protection Authority (1992) Criteria for the Assessment of Risk from Industry - Expanded Discussion. EPA Bulletin 627, May 1992.

Environmental Protection Authority (1993) Draft Western Australian Water Quality Guidelines for Fresh and Marine Waters. Bulletin 711, Environmental Protection Authority, Western Australia.

Environmental Protection Authority (1997) Midwest Iron and Steel Project, Geraldton Steel Plant, Narngulu Industrial Estate, Geraldton - Increase in production from 1.0 Mt/a to 2.4 Mt/a. Environmental Protection Authority Bulletin 858, June 1997

Environmental Protection Authority (1997) Policies, Guidelines and Criteria for Environmental Impact Assessment: Reducing Greenhouse Gas Emissions. Draft Policy No. 12. EPA, August 1997.

ERM Mitchell McCotter (1997) Accoustic modelling of train noise, Prepared for North Ltd, 8 September 1997, Pierce Calibration Laboratory.

Gentilli, J. (1972) Australian Climate Patterns. Nelson.

Gentilli, J. (1993) Floods in the desert - heavy rains in the dry regions of Western Australia. *W.A. Nat.* 19:201-219.

Green, R.H. (1979) "Sampling design and statistical methods for environmental biologists." Wiley and Sons, New York. 257pp.

Halpern Glick Maunsell (1992) Drainage Management Programme for the Mesa J Project for Robe River Iron Associates, January 1992.

Hirschberg K. J. B. (1993) Geological and hydrogeological guidelines for landfill site selection. Geological Survey of Western Australia

Integrated Environmental Services (1978) The Biological Environment of the West Angelas Area Western Australia. Prepared for Cliffs International Inc., April 1979.

Jarvis, N.T. (editor) (1979) Western Australia. An Atlas of Human Endeavour 1829-1979. Government Printer, Western Australia, Perth. pp 144.

Karijini Aboriginal Corporation Inc (KAC) (1991) A Report of the Work Area Clearance Survey of TR 5623 and the Western Corridor at Marandoo. Prepared for WA Government.

Kinhill Riedel & Byrne (1991) Iron Ore Stockpiles Extension Impacts of Seawall Construction. Unpublished Report for Robe River Iron Associates, June 1991.

Kirk, J.T.O. (1986) Optical limnology- A manifesto. In Limnology in Australia". Eds P De Deckker and W.D. Williams. CSIRO, Melbourne.

Lemly, A.D. (1982) Modification of benthic insect communities in polluted streams: 245.

Lieske, E. & Myers, R. (1994) Coral Reef Fishes. Harper Collins.

Macleod, J. & Gerhardy, S. (1996) Minerals in Western Australia: Bedrock of the Economy. Chamber of Mines and Energy of Western Australia Inc.

Masini, R. J. & Walker, D. (1989) Inland waters of the Pilbara, Western Australia Part 2. Environmental Protection Authority Technical Series 24

Masini, R.J. (1988) Inland waters of the Pilbara, Western Australia Part 1. Environmental Protection Authority Technical Series 10.

Maunsell & Partners. (1982) Environmental study for channel dredging spoil disposal areas at Cape Lambert Part 1 Potential for remobilisation of deposited dredge spoil.

Meagher T. D. & Associates. (1982) Environmental study for channel dredging spoil disposal areas at Cape Lambert Part 1 Environmental study.

Milewski, A.V. (1981) A comparison of vegetation height in relation to the effectiveness of rainfall in the mediterranean and adjacent arid parts of Australia and South Africa. *J. Biogeog.* 8: 107-116.

Muir, B. (1983) A Fauna Survey of the Hamersley Range National Park Western Australia 1980. Muir. B. (Ed) Bulletin No. 1. National Parks Authority of Western Australia, Nedlands, WA.

Mulvaney, K.J. (1984) A Survey for the ethnographic and archaeological Sites: Tom Price North Road, Pilbara, W.A. Report to the MRD Perth.

Newbury, R.W. and Gaboury, M.N. (1993) Stream Analysis and Fish Habitat Design. Newbury Hydraulics Ltd, Gibsons, BC. 256 pp.

North Limited (1997) Robe River Iron Associates Cape Lambert and Panawonica Action Plan for the Greenhouse Challenge Program, Draft for discussion May 1997

O'Brien, B. & Associates Pty Ltd (1992) Marandoo Iron Ore Mine and Central Pilbara Railway, Environmental Review and Management Program. Prepared for Hamersley Iron Pty. Ltd., February 1992.

O'Connor, R. (1993) Report of a preliminary Aboriginal consultation concerning Robe River mining company leases in the West Angelas region. Prepared for Robe River Mining Co. Pty. Ltd., October 1993.

O'Connor, R. (1997a) Report on a preliminary ethnographic investigation of the proposed West Angelas railway route. Prepared for Robe River Mining Co. Pty. Ltd., April 1997.

O'Connor, R. (1997b) Report on an ethnographic survey of exploration leases E47/797 and E47/798. Prepared for Robe River Mining Co. Pty. Ltd., June 1997.

O'Connor, R. (1997c) Report on an ethnographic survey of the proposed Wet Angelas railway route and the West Angelas gas and water pipeline routes. Prepared for Robe River Mining Co. Pty. Ltd., October 1997.

Palmer, K. (1977) The West Angelas Project: A preliminary survey for Aboriginal sites. *In* Proposal for archaeological and anthropological survey of the West Angelas Project area and railway line. Prepared for Cliffs International Inc., September 1997.

Palmer K. (1978a) An archaeological survey of Aboriginal sites in the West Angelas area. Prepared for Cliffs International Inc., July 1978.

Palmer, K. (1978b) An Archaeological Survey of the Proposed Railway Line Route: West Angelas Project, Part 1. Prepared for Cliffs International Inc., November 1978.

Palmer, K. (1979a) An Archaeological Survey of the Proposed Railway Line Route: West Angelas Project, Part 2. Prepared for Cliffs International Inc., July 1979.

Palmer K. (1979b) The West Angelas Project: An anthropological survey. Prepared for Cliffs International Inc., December 1979.

Palmer, K. (1980a) An archaeological survey TR 6998 and 6999. Prepared for Texasgulf Australia.

Palmer, K. (1980b) A supplementary report on archaeological sites on TR 6998- h. Prepared for Texasgulf Australia.

Pierce Calibration Laboratory & Mitchell McCotter (1997) Acoustic Modelling of Train Noise Prepared for North Limited, September 1997.

Pilbara Development Commission (1996) Pilbara Economic Perspective. Department of Commerce and Trade and the Pilbara Development Commission, July 1996.

Pilbara Development Commission (1997) Pilbara Land Use Strategy. Pilbara Development Commission, July 1997.

Quartermaine, G.S. (1989) Report on further archaeological survey work for the proposed Tom Price North Road. Prepared for MRD, Port Hedland.

Quartermaine, G. (1991) Report on an archaeological investigation, Marandoo Railway Corridor and Associated Works. Prepared for Hamersley Iron Pty Limited.

Quartermaine, G. (1992a) Report on an archaeological investigation, Juna Downs - E47/584. Prepared for Hamersley Iron Pty Limited.

Quartermaine, G. (1992b) Addendum to the report on an archaeological investigation, Marandoo Railway Corridor and Associated Works. Prepared for Hamersley Iron Pty Limited.

Quartermaine, G. (1995) Report on further archaeological investigations, Juna Downs - E47/584 & E47/631. Prepared for Hamersley Iron Pty Limited.

Quartermaine, G. (1996) Report on an Aarchaeological survey for Aboriginal sites, Proposed Hamersley Yandi Project Rail Corridor and Associated Infrastructure. Prepared for Hamersley Iron Pty Limited.

Quartermaine, G. (1997a) Report on a preliminary archaeological investigation for Aboriginal sites: alternative rail routes, proposed West Angelas Development, Volume 1. Prepared for Robe River Mining Co. Pty. Ltd., April 1997.

Quartermaine, G. (1997b) Report on a preliminary archaeological investigation for Aboriginal sites: alternative rail routes, proposed West Angelas Development, Volume 2. Prepared for Robe River Mining Co. Pty. Ltd., April 1997.

Robe River Iron Associates (1996) West Angelas 25 Mtpa Development: Appendix Geology and Iron Resources. Report prepared by Robe River Iron Associates, May 1996.

Robe River Iron Associates (1997a) West Angelas Scoping Study. Report prepared by Robe River Iron Associates, April 1997.

Robe River Iron Associates (1997b) West Angelas Preliminary Engineering Study Review of West Angelas Village Site. Report prepared by Robe River Iron Associates, July 1997.

Strahler, A.N. (1957) Quantitative analysis of watershed geomorphology. Trans. Am. Geophys. Un., 38: 913-920.

Streamtec (1997) West Angelas Iron Ore Project ERMP - Surface Water Hydrology and Watercourses. Report prepared for Robe River Iron Associates, September 1997.

Streamtec (1997a) Aquatic Ecosystem Study: Mesa J. Unpublished Report to Robe River Iron Assoc. Perth.

Streamtec (1997b) Panna wonica Iron Project ML248SA Annual Environmental Review, March 1997. Report ST12/97.

Trudgen, M. (1995a) A Flora Survey of Deposit 'A' near West Angela Hill, with Description of Vegetation of Flora Collecting Sites. Unpublished Report Prepared for Robe River Iron Associates, August 1995.

Trudgen, M. (1995b) Preliminary Flora Survey of Deposit 'B' near West Angela Hill, with Description of Vegetation of Flora Collecting Sites. Unpublished Report Prepared for Robe River Iron Associates, August 1995.

Trudgen, M. E. and Casson, N. (1998) Flora and Vegetation Surveys of Orebody A and Orebody B in the West Angela Hill area, an area surrounding them, and of rail route options considered to link them to the existing Robe River Iron Associates rail line. Unpublished Report Prepared for Robe River Iron Associates, March 1998.

Tyler, I.M., W.M. Hunter and I.R. Williams (1991) Newman, Western Australia. 1: 250 000 Geological Series - Explanatory Notes. Geological Survey of Western Australia.

Water and Rivers Commission (1996) Pilbara Region Water Resources Review and Development Plan 1996 Water and Rivers Commission Report WRAP 4, 1996.

Water Authority of Western Australia (1989) Stream salinity and its reclamation in south-west Western Australia. WAWA, Perth.

Western Australian Planning Commission (1997) Karratha Area Development Strategy. WAPC, April 1997.

Western Australian Plannning Commission (1996) State Planning Strategy. WAPC, November 1996.

Weston A. S. (1997) A vegetation and flora survey of a proposed route for a gas pipeline from the GGT pipeline to the West Angelas project area. Prepared for Robe River Iron Associates

Williams, W.D. & Buckney, R.T. (1976) Chemical composition of some inland surface waters in south, western and northern Australia. *Aust. J. Mar. Freshw. Res.* 27:379-397.

Woodward-Clyde (1997) Groundwater resource assessment - Turee Creek (Option B) Unpublished Report prepared for Robe River Mining 5 December 1997.

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APPENDIX A

EPA Guidelines for the Preparation of the Environmental Review and Management Program

Environmental Protection Authority
Draft Guidelines

WEST ANGELAS IRON ORE PROJECT

(Assessment Number 1144)

Part A	Specific Guidelines for the preparation of the Environmental Review and Management Programme
Part B	Generic Guidelines for the preparation of an environmental review document

Attachment 1	Example of the invitation to make a submission
Attachment 2	Advertising the environmental review
Attachment 3	Summary of proposal

These guidelines are provided for the preparation of the proponent's environmental review document. The specific environmental factors to be addressed are identified in Part A. The generic guidelines for the format of an environmental review document are provided in Part B.

Part A: Specific Guidelines for the preparation of the Environmental Review and Management Programme

1. The proposal

Robe River Mining Co. Pty. Ltd. (the proponent) intends to develop an iron ore mine 130 km west of Newman and facilities for the transport of ore to Cape Lambert and export from this destination. The transport components would comprise a rail link between the West Angelas mining areas and Cape Lambert and also an upgrade of the Cape Lambert facilities. A summary of the proposal is contained in Attachment 3 which also includes figures of the project area which will be referred to in this section.

Key aspects of the proposal are further summarised below.

Mine

It is proposed to mine some or all of a number of known deposits at the West Angelas site (130 km west of Newman, refer to Figure 1 of Attachment 3) which contain an estimated 950 million tonnes of iron resources. The project will have a mining and production capacity of 20 million tonnes per annum. Mining and associated facilities will include:

- a number of open cut pits;
- crushing and screening facilities;
- overland conveyor between Deposit B and Deposit A;
- fines desliming and beneficiation;
- tailings dam;
- product stockpiles;
- loadout facilities;
- borefield;
- gas fire power station or overhead transmission line;
- airstrip; and
- accommodation village.

The general mine layout is illustrated in Figure 3 of Attachment 3.

Railway

Transport of iron ore to Cape Lambert will require the construction of a railway from the mine-site to a point south of Cape Lambert, where it will connect to the existing Pannawonica - Cape Lambert Railway.

Although there are a number of options for the detailed route of the railway, the general route is as follows. The route commences at the West Angelas site and proceeds north-west to the point on the eastern boundary of the Karijini National Park. It then enters the park along a corridor excised from the national park in 1991 and parallels the existing Marandoo - Homestead Junction railway to Marandoo on the western boundary of the park. The route then parallels the Paraburdoo - Dampier Railway to the north for approximately 60 km to a point south of the Millstream - Chichester National Park. From here it crosses the Millstream - Chichester

National Park to meet up with the Pannawonica - Cape Lambert Railway in the north-east corner of the park.

The general railway route including a number of alternative routes (options) is depicted in Figure 4 of Attachment 3.

Cape Lambert

To allow for the train unloading, product stockpiling, and shipping of West Angelas ore, the Cape Lambert facility will require an upgrade. This upgrade would involve the construction of a new shiploader, an extension of the existing wharf, possible reclamation of 40 hectares of land, and the construction of a number of ancillary land-based structures.

A more detailed description of the proposed upgrading of the Cape Lambert facility is contained in Section 2.4 of Attachment 3

2. Environmental factors relevant to this proposal

At this preliminary stage, the Environmental Protection Authority (EPA) believes the relevant environmental factors, objectives and work required is as detailed in the table below:

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
BIOPHYSICAL			
Vegetation communities		Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.	Baseline studies to identify existing vegetation communities. Assessment of potential impacts (direct and indirect) on vegetation communities as a result of mining activities and railway construction. Proposed measures to manage impacts.
Declared Rare and Priority Flora		Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950.	Baseline studies to identify any Declared Rare and/or Priority Flora. Assessment of potential impacts (direct and indirect) on Declared Rare and Priority Flora as a result of mining activities and railway construction. Proposed measures to manage impacts.
Terrestrial Fauna		Maintain the abundance, species diversity and geographical distribution of terrestrial fauna.	Baseline studies to identify existing terrestrial fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on terrestrial fauna as a result of mining and associated activities. Proposed measures to manage impacts.

Specially Protected (Threatened) Fauna		Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950.	Baseline studies to identify existing threatened fauna throughout the areas to be affected by the proposal. Assessment of potential impacts (direct and indirect) on specially protected (threatened) fauna as a result of mining and associated activities. Proposed measures to manage impacts.
Marine Flora		Maintain the ecological function, abundance, species diversity and geographic distribution of marine flora, including mangroves.	Baseline studies to identify existing marine flora, including mangroves, around the proposed wharf extensions at Cape Lambert. Assessment of the potential impacts (direct and indirect) on marine flora, including mangroves, as a result of upgrading of the Cape Lambert facilities. Proposed measures to manage impacts.
Marine Fauna		Maintain the abundance, species diversity and geographic distribution of marine fauna.	Baseline studies to identify existing marine fauna around the proposed wharf extensions at Cape Lambert. Assessment of the potential impacts (direct and indirect) on marine fauna as a result of upgrading of the Cape Lambert facilities. Proposed measures to manage impacts.
Specially Protected (Threatened) Marine Fauna		Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950.	Baseline studies to identify existing threatened marine fauna around the proposed wharf extensions at Cape Lambert. Assessment of the potential impacts (direct and indirect) on threatened marine fauna as a result of upgrading of the Cape Lambert facilities. Proposed measures to manage impacts.

Watercourses		Maintain the integrity, functions and environmental values of drainage systems.	Baseline studies to identify watercourses, and types of surface water flow throughout the areas to be affected by the proposal. Baseline studies of wetlands throughout the areas to be affected by the proposal. Assessment of the potential impacts on surface water flow rates, drainage patterns, water shadow effects, sediment transport, riparian vegetation, and wetlands, as a result of mining activities and railway construction. Proposed measures to manage impacts.
Groundwater		Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	Detail of water requirements for the mining, processing, and other associated operations (including dewatering). Assessment of the implications this may have on regional groundwater. Proposed measures to manage impacts.
Landform		Establish stable, sustainable landform consistent with surroundings.	Assessment of potential impacts of the proposal, including the mine, railway, and port, on existing landforms. Detail of measures proposed to rehabilitate the impacted areas to an acceptable standard which will integrate the post mining landform with the surrounding environment. Assessment of potential impacts on visual amenity due to the development of the mine site and infrastructure associated with the mine site. Proposed measures to manage impacts.

POLLUTION MANAGEMENT			
Particulates / Dust		Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards.	Assessment of potential increase in dust resulting from the construction and operation of the mine, infrastructure, the upgrade of the Cape Lambert facilities, and other associated activities. Assessment of potential impacts of increased dust on the amenity of surrounding land users from the construction and operation of the mine and associated activities. Proposed measures to manage impacts. Baseline studies to identify areas likely to contain asbestos and the form of this asbestos. Assessment of the potential risk to the public from mining operations and the decommissioned pits. Proposed measures to manage risk.
Greenhouse gases		Ensure that greenhouse gas emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise greenhouse gas discharge).	Detail of potential sources of greenhouse gases and estimates of the quantities of these gases produced annually.
Gaseous emissions	SO_2	Ensure that SO_2 emissions meet the air quality standards and limits stated in the Kwinana EPP and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise SO_2 discharge).	Estimate quantities and concentrations of SO_2 emissions which will be generated by the project, in particular, the power station. Comparison of estimates with relevant standards and limits. Proposed measures to minimise SO_2 emissions.

Gaseous emissions	NOx	Ensure that NOx emissions meet acceptable standards and requirements of Section 51 of the Environmental Protection Act 1986 (all reasonable and practicable measures are taken to minimise NOx discharge).	Estimate quantities and concentrations of NO_x emissions which will be generated by the project, in particular, the power station. Comparison of estimates with relevant standards and limits. Proposed measures to minimise NO_x emissions.
Groundwater quality		Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Detail of water requirements for the mining, processing, and other associated operations. Detail of drainage, dewatering, and fate of water used/pumped. Detail of the possibility of acid mine drainage occurring, and potential impacts on the surrounding environment. Assessment of the implications this may have on local and regional groundwater quality. Proposed measures to manage impacts.
Surface water quality		Maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993).	Detail of water requirements for the mining, processing, and other associated operations. Detail of site drainage, dewatering, and fate of water used/pumped. Detail of the possibility of acid mine drainage occurring, and potential impacts on the surrounding environment. Assessment of the implications this may have on local and regional surface/ground water quality. Proposed measures to manage impacts.

Marine water and sediment quality		Maintain or improve the quality of marine water consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993). Maintain or improve marine water and sediment quality consistent with Environmental Quality Objectives (EQO's) and Environmental Quality Criteria (EQC's) defined in the Southern Metropolitan Coastal Waters Study (1996).	Assessment of the potential impacts on marine water quality as a result of activities associated with the upgrade and operation of the Cape Lambert facility. Proposed measures to manage impacts.
SOCIAL SURROUNDINGS			
Heritage	Aboriginal culture and heritage Non-indigenous heritage	Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972; and Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area. Comply with statutory requirements in relation to areas of cultural or historical significance.	Identify Aboriginal cultural and heritage sites of significance through archaeological and ethnographic surveys of the project area and through consultation with local Aboriginal groups and the Aboriginal Affairs Department. Identify any non-indigenous heritage sites. Identify potential impacts on any identified sites. Proposed measures to manage impacts.
Public health and safety	Risk and hazard	Ensure that risk is managed to meet the EPA's criteria for individual fatality risk off-site and the DME's requirements in respect of public safety.	Identification of the hazards and an assessment of the risks associated with the project, in particular, those associated with the operation of the natural gas pipeline. Proposed methods to reduce both hazards and risk.

OTHER			
Conservation Reserves (Millstream-Chichester National Park and Karijini National Park)	Ecological function, public use and amenity.	Ensure that the functions of Conservation Reserves are not compromised.	Baseline studies of each rail route option covering the following topics: • vegetation/flora; • fauna and habitats; • landscape; • visual amenity; • noise; • watercourses/drainage patterns; and • public use. Assessment of the potential impacts of each route on the functions of the National Park having regard to the topics identified above. Comparison/ranking of the impacts for each alternative option. Proposed measures to manage impacts.

These factors should be addressed within the environmental review document for the public to consider and make comment to the EPA. The EPA expects to address these factors in its report to the Minister for the Environment.

In addition to the environmental review document, the proponent must also prepare a summary of this document which is to be made freely available to the public coincident with the public review period.

The EPA expects the proponent to take due care in ensuring any other relevant environmental factors which may be of interest to the public are addressed.

3. Availability of the environmental review

3.1 Copies for distribution free of charge

Supplied to DEP:

- Library/Information Centre..... 9
- EPA members..... 6
- Officers of the DEP (Perth) 6

Distributed by the proponent to:

Government departments	• Pilbara Development Commission ..... 1 • Department of Minerals and Energy..... 2 • Department of Resources Development..... 1 • Department of Conservation and Land Management..... 3 • Pollution Prevention Division, Department of Environmental Protection..... 1 • National Parks and Nature Conservation Authority ..... 1 • Aboriginal Affairs Department..... 2 • Main Roads Department ..... 1 • Water and Rivers Commission..... 2
Local government authorities	• Shire of East Pilbara ..... 1 • Shire of Ashburton ..... 1 • Shire of Roebourne..... 1
Libraries	• J S Battye Library ..... 3 • The Environment Centre..... 2 • South Hedland Public Library ..... 2 • Karratha Public Library..... 2 • Wickham Community Library ..... 2 • Roebourne Community Library 2
Other	• Conservation Council of WA ..... 1 • Karijini Aboriginal Corporation ..... 1 • Gumala Aboriginal Corporation ..... 1 • Nanga-Ngoona Moora Joorga Land Council 1

3.2 Available for public viewing

- J S Battye Library;
- South Hedland Public Library;
- Karratha Public Library; and
- Department of Environmental Protection Library.

Part B: Generic Guidelines for the preparation of an environmental review document

1. Overview

All environmental reviews have the objective of protecting the environment. Environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe:

- the proposal;
- receiving environment;
- potential impacts of the proposal on factors of the environment; and
- proposed management strategies to ensure those environmental factors are appropriately protected.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to help the proponent to improve the proposal so the environment is protected. The DEP will co-ordinate, on behalf of the EPA, relevant government agencies and the public in providing advice about environmental matters during the assessment of the environmental review for this proposal.

The primary purpose of the environmental review is to provide information on the proposal within the local and regional framework to the EPA, with the aim of emphasising how the proposal may impact the relevant environmental factors and how those impacts may be mitigated and managed.

The language used in the body of the environmental review should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the environmental review. It should be noted that the environmental review will form the legal basis of the Minister for the Environment's approval of the proposal and therefore the environmental review should include a description of all the main and ancillary components of the proposal, including options where relevant.

Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinion, and each assessment should lead to a discussion of the management of the environmental factor.

2. Objectives of the environmental review

The objectives of the environmental review are to:

- place this proposal in the context of the local and regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management programme, which shows that the environmental impacts resulting from the proposal, including cumulative impact, can be acceptably managed; and
- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

3. Environmental management

The EPA expects the proponent to develop and implement an Environmental Management System appropriate to the proposal consistent with the principles outlined in the AS/NZS ISO 14000 series, including provisions for accountability review and a commitment to continuous improvement.

The key components which should be included in environmental review documentation, depending on the scale of the proposal, are environmental management:

- policy;
- resources budget;
- programme;
- plan(s);
- training programme;
- monitoring programme;
- contingency plan(s); and
- improvement plan(s).

Documentation on the relevant components should be proportional with the scale of the proposal and the potential environmental impacts. If appropriate, the documentation can be incorporated into a formal environmental management system and provision made for periodic performance review. Public accountability is a principle that should be incorporated into the approach on environmental management.

The environmental management programme is the key document that should be appropriately defined in an environmental review. The environmental management programme should provide plans to manage the relevant environmental factors, define the performance objectives, outline the operational procedures and outline the monitoring and reporting procedures which would demonstrate the achievement of the objectives.

4. Format of the environmental review document

The environmental review should be provided to the DEP officer for comment. At this stage the document should have all figures produced in the final format and colours.

Following approval to release the review for public comment, the final document should also be provided to the DEP in an electronic format.

The proponent is requested to supply the project officer with an electronic copy of the environmental review document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

5. Contents of the environmental review document

The contents of the environmental review should include an executive summary, introduction and at least the following:

5.1 The proposal

Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies; and
- consideration of alternative options.

Key characteristics

The Minister's statement will bind the proponent to implementing the proposal in accordance with any technical specifications and key characteristics[1] in the environmental review document. It is important therefore, that the level of technical detail in the environmental review, while sufficient for environmental assessment, does not bind the proponent in areas where the project is likely to change in ways that have no environmental significance.

Include a description of the components of the proposal, including the nature and extent of works proposed. This information could be presented in the form of a table as follows:

Table 1: Key characteristics (example only)

Element	Description
Life of project (mine production)	55 months
Size of ore body	682 000 tonnes
Area of disturbance	100 hectares
Ore mining rate • maximum • average	 • 200 000 tonnes per year • 160 000 tonnes per year
Background gamma radiation levels • maximum • average	 • 0.52 µGrey per hour • 0.16 m 0.08 µGrey per hour
Water supply • source • maximum hourly requirement • maximum annual requirement	 • Yarloop borefield, shallow aquifer • 180 cubic metres • 1 000 000 cubic metres
Heavy mineral concentrate transport • truck movements (maximum)	 • 75 return truck loads per week

[1] Changes to the key characteristics of the proposal following final approval, would require assessment of the change and can be treated as non-substantial and approved by the Minister, if the environmental impacts are not significant. If the change is significant, it would require assessment under section 38 or section 46. Changes to other aspects of the proposal are generally inconsequential and can be implemented without further assessment. It is prudent to consult with the Department of Environmental Protection about changes to the proposal.

The key characteristics table should be supplemented with figures to ensure that the proposal is clearly explained. Figures that should always be included are:

- a map showing the proposal in the local context - an overlay of the proposal on a base map of the main environmental constraints;
- a map showing the proposal in the regional context;

and, if appropriate:

- a process chart / mass balance diagram showing inputs, outputs and waste streams.

All figures should include a north arrow, a scale bar, a legend, grid co-ordinates, the source of the data, a title and (where applicable) the date of aerial photo.

Other logistics

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).

5.2 Environmental factors

The environmental review should focus on the relevant environmental factors for the proposal, and these should be agreed in consultation with the EPA and DEP and relevant public and government agencies. Preliminary environmental factors identified for the proposal are shown in Part A of these guidelines.

Further environmental factors may be identified during the preparation of the environmental review, therefore on-going consultation with the EPA, DEP and other relevant agencies is recommended. The DEP can advise the proponent on the recommended EPA objective for any new environmental factors raised. Minor matters which can be readily managed as part of normal operations for the existing operations or similar projects may be briefly described.

Items that should be discussed under each environmental factor are:

- a clear definition of the area of assessment for this factor;
- the EPA objective for this factor;
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all factors);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above;
- if not, environmental management proposed to ensure the EPA's objective is met;
- predicted outcome.

The proponent should provide a summary table of the above information for all environmental factors, under the three categories of biophysical, pollution management and social surroundings:

Table 2: Environmental factors and management (example only)

Environmental Factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome
BIOPHYSICAL					
vegetation community types 3b and 20b	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
POLLUTION MANAGEMENT					
Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week.	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
SOCIAL SURROUNDINGS					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Main building will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

5.3 Environmental management commitments

The implementation of the proposal and all commitments made by the proponent become legally enforceable under the conditions of environmental approval issued in the statement by the Minister for the Environment. All the key environmental management commitments should be consolidated in the public review document in a list (usually in an Appendix). This list is attached to the Minister's statement and becomes part of the conditions of approval.

The proponent's compliance with the key environmental management commitments will be audited by the DEP, so they must be expressed in a way which enables them to be audited.

A commitment needs to contain most of the following elements to be auditable:

- who (eg. the proponent)
- will do what (eg. prepare a plan, take action)

- why (to meet an environmental objective)
- where/how (detail the action and where it applies)
- when (in which phase, eg. before construction starts)
- to what standard (recognised standard or agency to be satisfied)
- on advice from (agency to be consulted).

The proponent may make other commitments, which address less significant or non-environmental matters, to show a commitment to good general management of the project. Such commitments would not normally be included in the list appended to the statement. The EPA expects that the proponent will audit these commitments by internal processes. Though the DEP would not subject the less significant environmental commitments to routine audit, it may periodically request that compliance with these commitments be demonstrated, so as to verify satisfactory environmental performance in the proponent's implementation of the proposal.

With the implementation of continuous improvement, the procedures to implement the commitments may need to be changed. These changes can be made in updates to the environmental management plan, whilst ensuring the objective is still achieved.

Once the proposal is approved, changes to the commitments constitute a change to the proposal and should be referred to the DEP.

Examples of the preferred format for typical commitments are shown in the following table:

Table 3: Summary of proponent's commitments (example only)

Commitment (Who/What)	Objective (Why)	Action (How/Where)	Timing (When)	Whose advice	Measurement/ Compliance criteria
1. XYZ Mining will develop a rehabilitation plan	to protect the abundance, species diversity, geographic distribution and productivity of the vegetation community types 3b and 20b	by limiting construction to a small area (10 ha) of Reserve 34587 and rehabilitating the area	before construction	CALM, NPNCA	fences built; species distribution and density consistent with vegetation community types 3b and 20b
2. XYZ Mining will minimise dust generation	to maintain the amenity of nearby land owners	by preparing and implementing a Dust Control Plan which meets EPA Dust Control criteria	before the start of construction phase	preparation: DEP; implementation: Shire	Letter from Shire submitted with Performance and Compliance Report.

Commitments should be written in tabular form, preferably with some specification of ways in which the commitment can be measured, or how compliance can be demonstrated.

Draft commitments which are not in a format that can be audited will not be accepted by project officers for public review documentation. Proponents will be assisted to revise inadequate commitments.

5.4 Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the environmental review. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

Attachment 1

The first page of the proponent's environmental review document must be the following invitation to make a submission, with the parts in square brackets amended to apply to each specific proposal. Its purpose is to explain what submissions are used for and to detail why and how to make a submission.

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

[the proponent] proposes [the rezoning of land and the development of a Marina Complex in the City of Bunbury]. In accordance with the Environmental Protection Act, a [PER] has been prepared which describes this proposal and its likely effects on the environment. The [PER] is available for a public review period of [8] weeks from [**date**] closing on [**date**].

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the [PER] or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the [PER]:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the [PER];
- if you discuss different sections of the [PER], keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: [**date**]

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: **[Project Officer name]**

Attachment 2

Advertising the environmental review

The proponent is responsible for advertising the release and arranging the availability of the environmental review document in accordance with the following guidelines:

Format and content

The format and content of the advertisement should be approved by the DEP before appearing in the media. For joint State-Commonwealth assessments, the Commonwealth also has to approve the advertisement. The advertisement should be consistent with the attached example.

Note that the DEP officer's name should appear in the advertisement.

Size

The size of the advertisement should be two newspaper columns (about 10 cm) wide by about 14 cm long. Dimensions less than these would be difficult to read.

Location

The approved advertisement should, for CER's, appear in the news section of the main local newspaper and, for PER's and ERMP's, appear in the news section of the main daily paper's ("The West Australian") Saturday edition, and in the news section of the main local paper at the commencement of the public review period and again two weeks prior to the closure of the public review period.

Timing

Within the guidelines already given, it is the proponent's prerogative to set the time of release, although the DEP should be informed. The advertisement should not go out before the report is actually available, or the review period may need to be extended.

Example of the newspaper advertisement

SCM CHEMICALS LTD

Consultative Environmental Review

EXTENSION TO DALYELLUP RESIDUE DISPOSAL PROGRAMME

(Public Review Period: **[date]** to **[date]**)

SCM Chemicals Ltd is planning to extend the company's existing residue disposal programme at Dalyellup, south of Bunbury, from March 1992 to March 1993.

A Consultative Environmental Review (CER) has been prepared by the company to examine the environmental effects associated with the proposed development, in accordance with Western Australian Government procedures. The CER describes the proposal, examines the likely environmental effects and the proposed environmental management procedures.

SCM has prepared a project summary which is available free of charge from the company's office on Old Coast Road, Australind.

Copies of the CER may be purchased for $5 from:

SCM Chemicals Ltd
Old Coast Road
AUSTRALIND WA 6230
Telephone: (08) 9467 2356

Copies of the complete Consultative Environmental Review will be available for examination at:

- Environmental Protection Authority
  Library Information Centre
  8th Floor, Westralia Square
  38 Mounts Bay Road
  PERTH WA 6000
- Environmental Protection Authority
  65 Wittenoom Street
  BUNBURY WA 6230
- City of Bunbury public libraries
- Shire of Capel libraries
- Shire of Harvey library (Australind)
- Shire of Dardanup (Eaton)

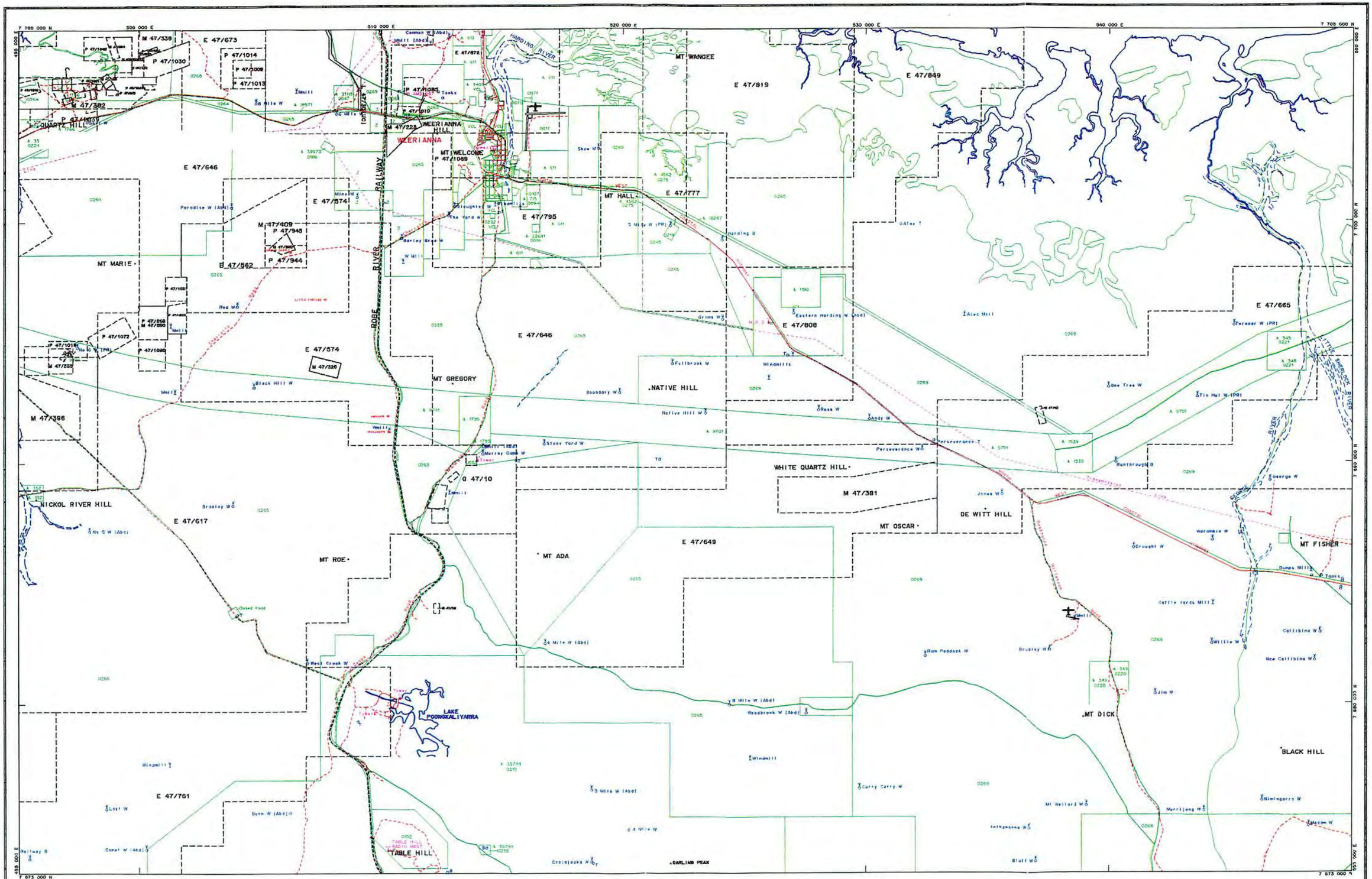
Submissions on this proposal are invited by **[closing date]**. Please address your submission to:

Chairman
Environmental Protection Authority
8th Floor, Westralia Square
38 Mounts Bay Road
PERTH WA 6000
Attention: **[Project Officer name]**

If you have any questions on how to make a submission, please ring the project officer, **[Project Officer name]**, on (08) 9222 7xxx.

APPENDIX B

Rail routes



LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
- ROAD (SEALED)
- ROAD (UNSEALED)
- TRACK
- ROAD : PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
- GAS PIPELINE
- GAS PIPELINE : PROPOSED
- POWERLINE
- POWERLINE : PROPOSED
- FENCE
- NATIONAL PARK
- CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
- WATER PIPELINE PROPOSED
- CONSTRUCTION CAMP

SHEET INDEX

1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4188-1.0	Report	1997
Water Sources	GROUNDWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	CMPS & F	0401	Graphical	1994
Mine Layout	RRIA	SK7895	Graphical	MAY 1996
Mine Services	Cmegear	SK7367	Digital	1998

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

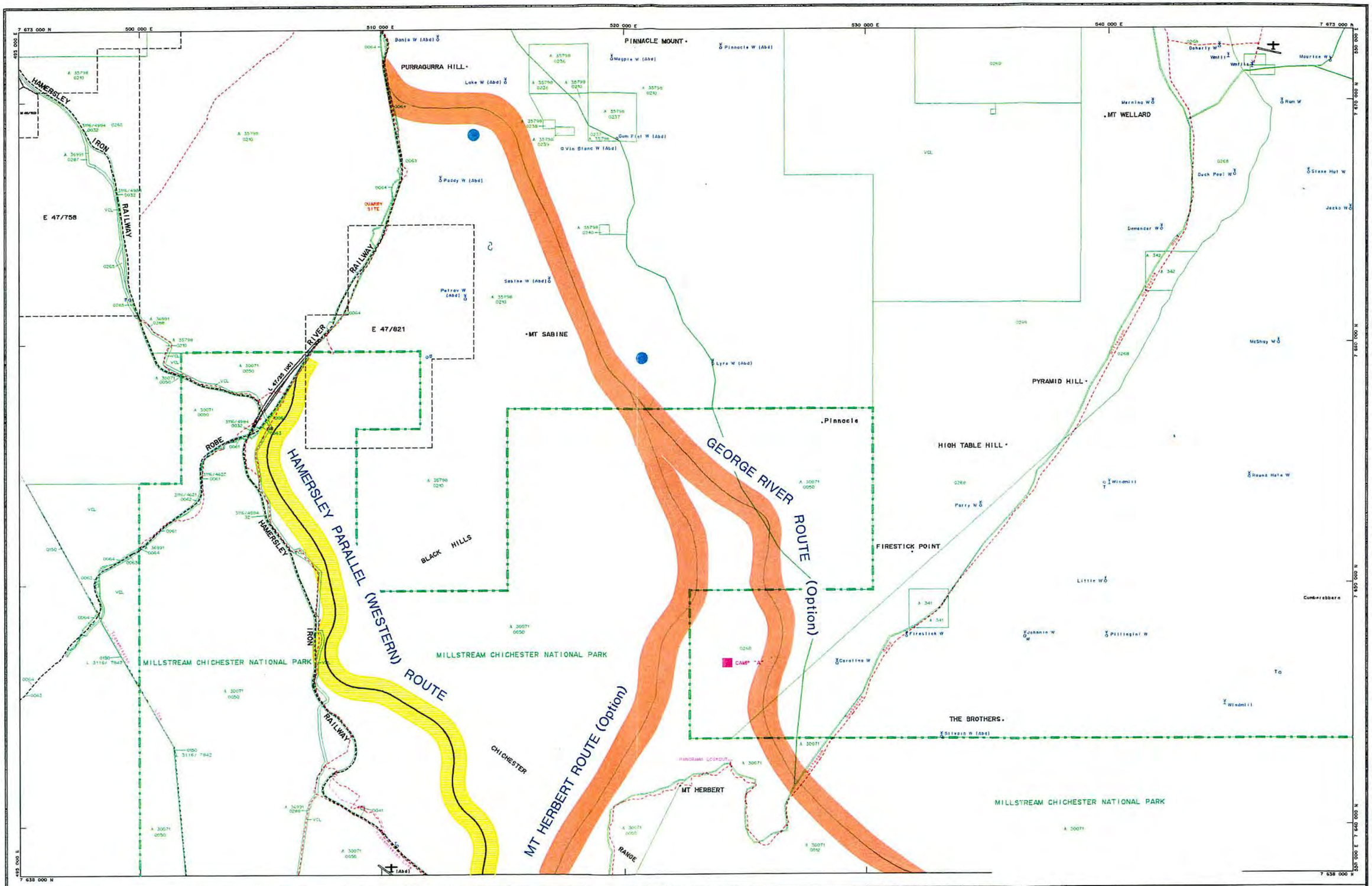
Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324581, April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG	CONST	CLIENT
2	16/5/98	DEVELOPMENT LOCATIONS REVISED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE: 1 : 150 000	DRAWN BY: AAM	DATE: 7/5/97	
FILE No: 324581	CHECKED BY: AAM	DATE: 7/5/97	
DRAWING No: 324538-2	REV: 2		



LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
- ROAD (SEALED)
- ROAD (UNSEALED)
- TRACK
- ROAD - PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
- GAS PIPELINE
- GAS PIPELINE : PROPOSED
- POWERLINE
- POWERLINE : PROPOSED
- FENCE
- NATIONAL PARK
- CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
- WATER PIPELINE PROPOSED
- CONSTRUCTION CAMP

SHEET INDEX

1 2 3 4 5 6 7 8 9 10 11 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4180-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	CAPS G F	0401	Graphical	1994
Mine Layout	BRIA	SKP896	Graphical	MAY 1996
Mine Services	C/Wagner	SKP387	Digital	1998

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324581. April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD
5	10/12/97	DEVELOPMENT LOCATIONS REVISED	RC	PB
4	10/9/97	GEORGE RIVER ALIGNMENT DELETED DEVELOPMENT AREAS REVISED	RC	PB
3	10/9/97	MT HERBERT ALIGNMENT REVISED	RC	PB
2	9/9/97	DEVELOPMENT AREA REVISED	RC	PB
1	7/5/97	ISSUED	RC	PB
0	17/4/97	ISSUED	RC	PB

ENG. CONST. MGT. CLIENT

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE: 1 : 150 000 | DRAWN BY: AAM | DATE: 7/5/97
FILE No.: 324581 | CHECKED BY: AAM | DATE: 7/5/97
DRAWING No.: 324581-3 | REV.: 5

MT HERBERT ROUTE (Option)

HAMERSLEY PARALLEL (WESTERN) ROUTE

MILLSTREAM CHICHESTER NATIONAL PARK

BAROWANNA HILL

MT LEAL

MT MONTAGU

CHICHESTER

MT RICHTHOFEN

RANGE

GEORGE RIVER ROUTE (Option)

MT LEAL ROUTE

EXISTING HAMERSLEY ROUTE (Option)

HAMERSLEY IRON RAILWAY

MILLSTREAM HILL

Hay Stack Flat

DEVELOPMENT AREA
CADASTRE : LAND ACT
CADASTRE : MINING ACT
ROAD (SEALED)
ROAD (UNSEALED)
TRACK
ROAD : PROPOSED
RAILWAY
RAILWAY : PROPOSED
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Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4186-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	DMPS & F	0407	Graphical	1994
Mine Layout	RRIA	SK7895	Graphical	MAY 1996
Mine Services	C/Wagner	SK7387	Digital	1996

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES, AAM Surveys Ref. 324681, April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST ENG	CLIENT
4	16/5/97	DEVELOPMENT LOCATIONS REVISED	RC	PB			
3	9/5/97	DEVELOPMENT AREA REVISED	RC	PB			
2	29/4/97	MT HERBERT ALIGNMENT REVISED	RM	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS
IRON ORE DEVELOPMENT
PROJECT DEFINITION

SCALE: 1 : 150 000 | DRAWN BY: AAM | DATE: 7/5/97
FILE No.: 324681 | DESIGNED BY: AAM | DATE: 7/5/97
DRAWING No: 324538-4 | REV: 4

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540 000 E
550 000 E
560 000 E
570 000 E
580 000 E
7 603 000 N
535 000 E
590 000 E
7 560 000 N
7 580 000 N
7 570 000 N
7 568 000 N

SADDLE HILL*
MT MARGARET*
MT PARSONS*
HAMERSLEY RANGE
HAMERSLEY IRON RAILWAY
CAMP "B"
COOLAWANYAH
Chichester Downs
Deep W (Abd)
New No 8 BO
No 6 B
No 12 B (Abd)
No 5 W
No 25A BO
No 24A BO
No 31B B
No 31A B
No 30A BO
No 30B B
No 29A B
No 38 B
No 47B B
No 47A B
No 39A B
Thesmias W (Abd)
Webes BO
Bull Pad B
Jerrina W
Tempathanna W
Harman B
Guz Mill W
Slim B
Juttons W
Campbell B
Monty W
Garden W
1 Mile B
Jardine W
Lefroy W
12 Mile B
Old 12 Mile B (Abd)
Bloom W (Abd)
16 Mile B
Herdie W
Man-O-War W
Ball W
Lockwood W
Encounter W
Cement W
Nelson W
Farmer W
Quarrina W
Mulga B
Menzies B (Abd)
Jellicoe B
Head B
Torch B (Abd)
Bores
E 47/501
E 47/54
E 47/700
E 47/474
E 47/585
ML4SA Sec24
ML4SA Sec25
ML4SA Sec26
ML4SA Sec27
ML4SA Sec28
ML4SA Sec29
ML4SA Sec30
ML4SA Sec31
ML4SA Sec32
ML4SA Sec33
ML4SA Sec34
ML4SA Sec35
ML4SA Sec36
ML4SA Sec37

LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
- ROAD (SEALED)
- ROAD (UNSEALED)
- TRACK
- ROAD : PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
- GAS PIPELINE
- GAS PIPELINE : PROPOSED
- POWERLINE
- POWERLINE : PROPOSED
- FENCE
- NATIONAL PARK
- CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
- WATER PIPELINE PROPOSED
- CONSTRUCTION CAMP

SHEET INDEX

1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
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Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1998
Quarry / Borrow sites	Soil & Rock	4158-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	GAPS B.V.	0401	Graphical	1994
Mine Layout	RRIA	SKP835	Graphical	MAY 1996
Mine Services	C/Wagner	SKP387	Digital	1998

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

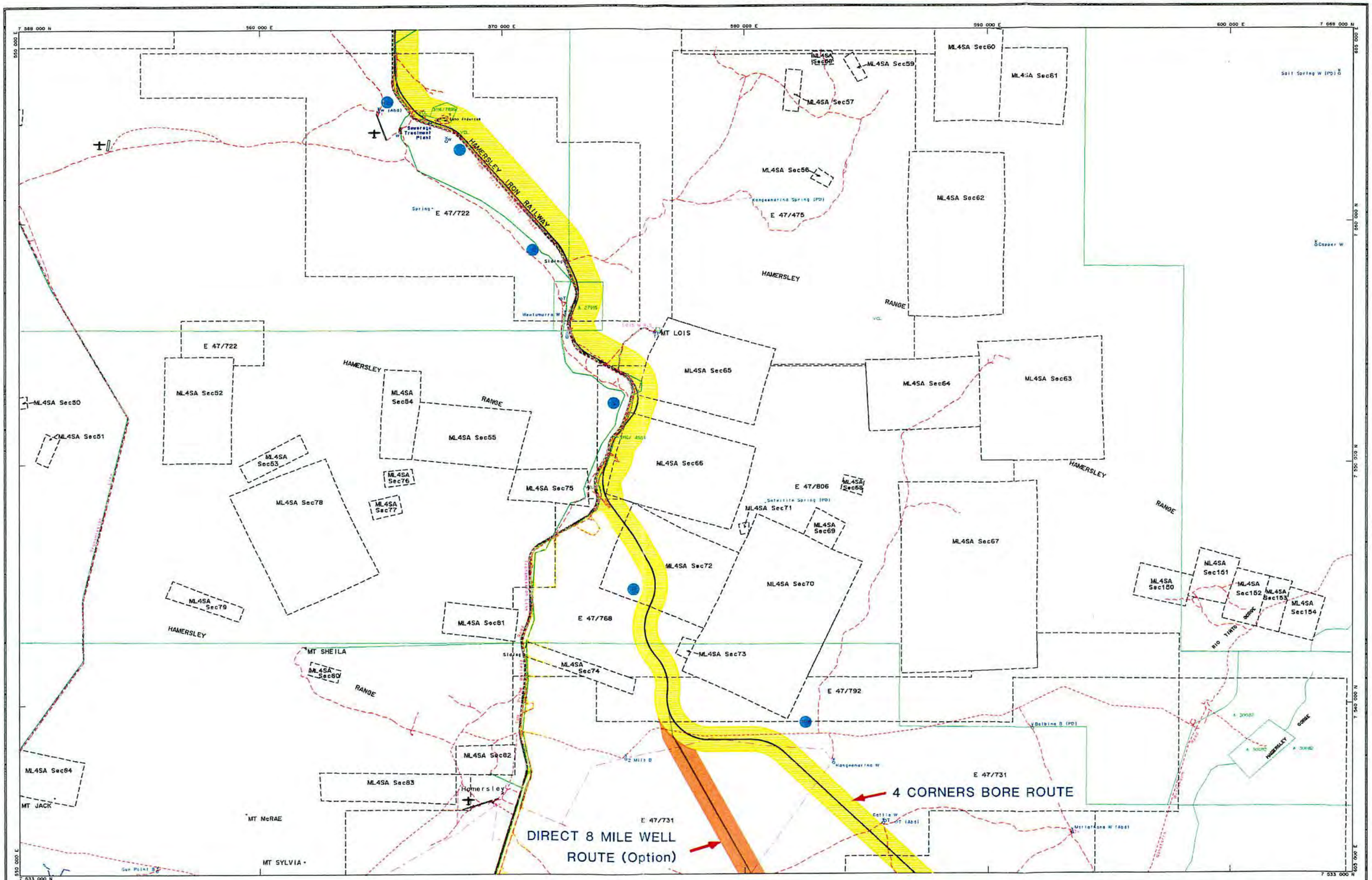
Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES, AAM Surveys Ref. 324581 - April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONSTR.	CLIENT
2	16/5/97	DEVELOPMENT OPTIONS REVISED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE: 1 : 150 000 — DRAWN BY: AAM — DATE: 7/5/97
FILE No: 324581 — CHECKED BY: AAM — DATE: 7/5/97
DRAWING No: 324538-5 — REV: 2



LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
- ROAD (SEALED)
- ROAD (UNSEALED)
- TRACK
- ROAD : PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
- GAS PIPELINE
- GAS PIPELINE : PROPOSED
- POWERLINE
- POWERLINE : PROPOSED
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- NATIONAL PARK
- CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
- WATER PIPELINE PROPOSED
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SHEET INDEX

1 2 3 4 5 6 7 8 9 10 11 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4188-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipeline	CMPS & F	6401	Graphical	1994
Mine Layout	RRIA	SKP995	Graphical	MAY 1996
Mine Services	C/Wagner	SK7387	Digital	1998

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 : 0 : 1 2km

Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324581: April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST. ENG.	CLIENT
4	16/2/98	DEVELOPMENT LOCATIONS REVISED	RC	PB			
3	16/9/97	ALTERNATIVE ROUTE ALIGNMENT	RC	PB			
2	20/5/97	ROSELLA CONNECTION ADDED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE 1 : 150 000	DRAWN BY: AAM	DATE: 7/5/97
FILE No: 324581	CHECKED BY: AAM	DATE: 7/5/97
DRAWING No: 324538-6		REV. 4

DIRECT 8 MILE
WELL ROUTE (Option)

4 CORNERS BORE ROUTE

HAMERSLEY
IRON
RAILWAY

ROSELLA
SIDING

HAMERSLEY
L 3114/1377

QUARRY SITE

"ALTERNATE" QUARRY SITE

CAMP "C"

RED HILL

E 47/603

E 47/537

E 47/538

HAMERSLEY
RANGE

MT MacLEOD

MT FREDERICK

MT STEVENSON

MT DE LA HUNTY

MT BRUCE

KARIJINI NATIONAL PARK

TR 5615H

TR 5617H

TR 5618H

TR 5619H

L 47/18

L 47/19

LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
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- ROAD (UNSEALED)
- TRACK
- ROAD : PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
- GAS PIPELINE
- GAS PIPELINE : PROPOSED
- POWERLINE
- POWERLINE : PROPOSED
- FENCE
- NATIONAL PARK
- CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
- WATER PIPELINE PROPOSED
- CONSTRUCTION CAMP

SHEET INDEX

1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	0490/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4188-1.0	Report	1997
Water Sources	HOOKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	CMPS & F	0401	Graphical	1994
Mine Layout	RRIA	SKP895	Graphical	MAY 1996
Mine Services	C/Wagner	SK9387	Digital	1958

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

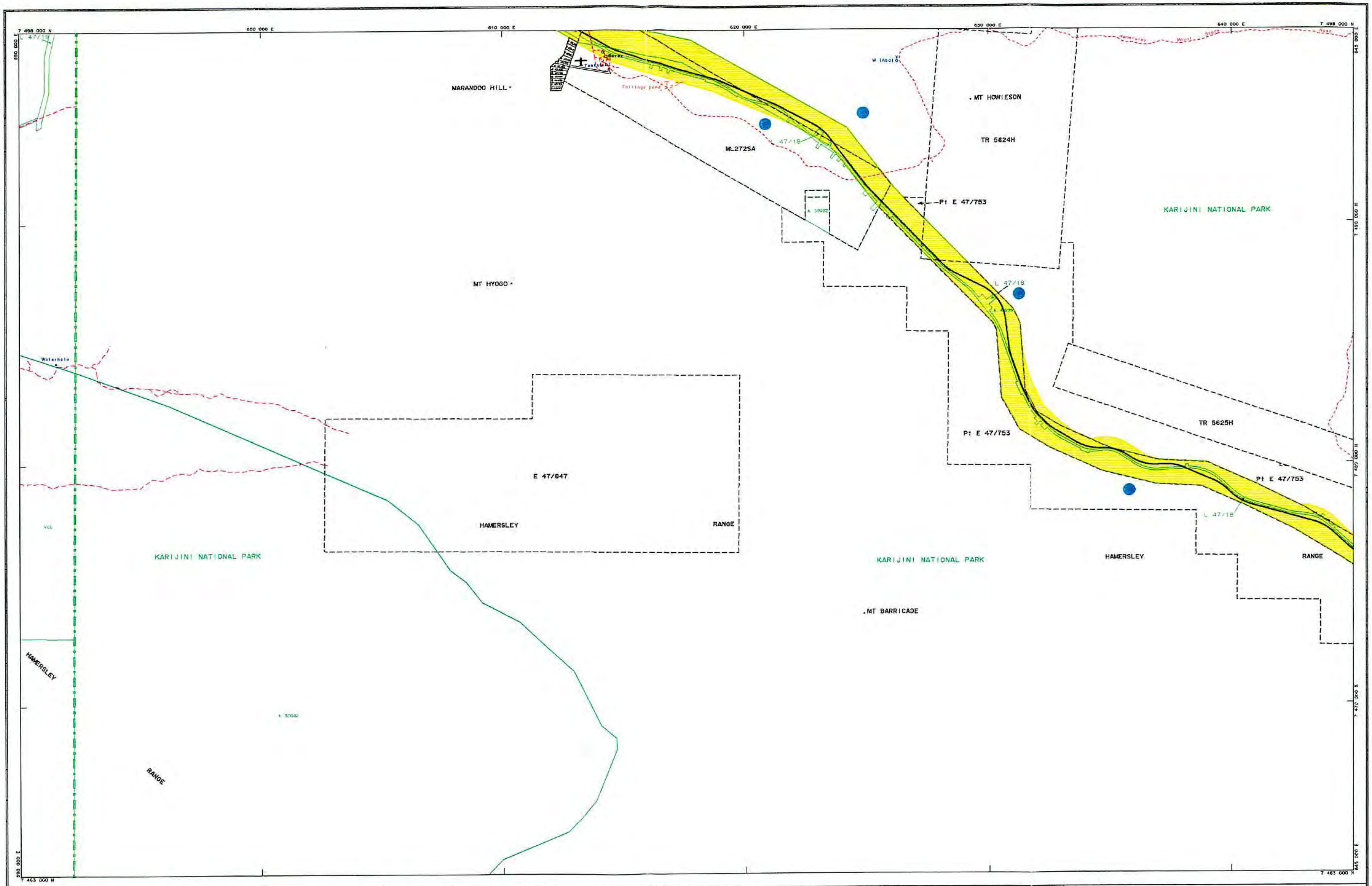
Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324081, April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST. MNG.	CLIENT
5	10/2/98	DEVELOPMENT LOCATIONS REVISED	RC	PB			
4	4/7/97	ROSELLA CONNECTION REVISED	RC	PB			
3	30/6/97	ALTERNATIVE ROUTE ALIGNMENT	RC	PB			
2	20/6/97	ROSELLA CONNECTION ADDED	RC	PB			
1	7/6/97	ISSUED	RC	PB			
0	27/4/97	ISSUED	RC	PB			

ROBE ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE:	1 : 150 000	DRAWN BY:	AAM	DATE:	7/5/97
FILE No:	324581	CHECKED BY:	AAM	DATE:	7/5/97
DRAWING No:	324538-7	REV:	5		



LEGEND

DEVELOPMENT AREA	RAILWAY
CADASTRE : LAND ACT	RAILWAY : PROPOSED
CADASTRE : MINING ACT	GAS PIPELINE
ROAD (SEALED)	GAS PIPELINE : PROPOSED
ROAD (UNSEALED)	POWERLINE
TRACK	POWERLINE : PROPOSED
ROAD : PROPOSED	FENCE

NATIONAL PARK
CONSTRUCTION WATER SITE OUTSIDE DEVELOPMENT AREA
WATER PIPELINE PROPOSED
CONSTRUCTION CAMP

SHEET INDEX
1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date	SOURCE DATA	Source	Ref No	Medium	Date
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Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97	Mine Layout	RRIA	SKP895	Graphical	MAY 1996
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97	Mine Services	C/Wagner	SKP387	Digital	1998
Rail Locations	GHD	5480/01/01	Digital	1998					
Quarry / Borrow sites	Soil & Rock	4188-1.D	Report	1997					
Water Sources	ROCKWATER	242.0/97/1	Report	1997					

INTENDED USE : Project Definition
LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE
1 0 1 2km

Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324581. April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST. ENG.	CLIENT
2	16/2/98	DEVELOPMENT LOCATIONS REVISED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE: 1 : 150 000	DRAWN BY: AAM	DATE: 7/5/97
FILE No: 324581	CHECKED BY: AAM	DATE: 7/5/97
DRAWING No: 324538-8		REV: 2

7 498 000 N
650 000 E
660 000 E
670 000 E
680 000 E
690 000 E
7 498 000 N
645 000 E
700 000 E
7 490 000 N
7 480 000 N
7 470 000 N
645 000 E
700 000 E
7 463 000 N

ML282SA
sec 8

MT WINDELL

E 47/796

ML270SA
sec 3

E 47/801

E 47/4

E 47/640

KARIJINI NATIONAL PARK

E 47/620

E 47/801

E 47/724

MT MOSSENSON

E 47/629

L 47/18

MT WILDFLOWER

TOWN HILL

E 47/631

E 47/584

TR3156H

E 47/629

CAMP "D"

PACKSADDLE HILL

Coffee BO
Rockridge BO
Munjina B
Corners B
Yarrintire B
Enterprise BO
Perishing Pool BO
Yandicoogina BO
JUNA DOWNS 3114 1191
Wireyard BO
Minigan B
OB (Abd)
Pens BO
No 33 BO
Red Hill BO
Taylor BO
Mick B
Well
Skingle B (PD)
16 Mile B
68 Mile B
Gewer BO
Camp 1/2 B
GREAT NORTHERN HIGHWAY

LEGEND

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- GAS PIPELINE : PROPOSED
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SHEET INDEX

1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	GHD	5480/01/01	Digital	1958
Quarry / Borrow sites	Soil & Rock	4186-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	CMPS & F	0401	Graphical	1994
Mine Layout	RRIA	SK7095	Graphical	MAY 1996
Mine Services	C/Wagner	SK7387	Digital	1996

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

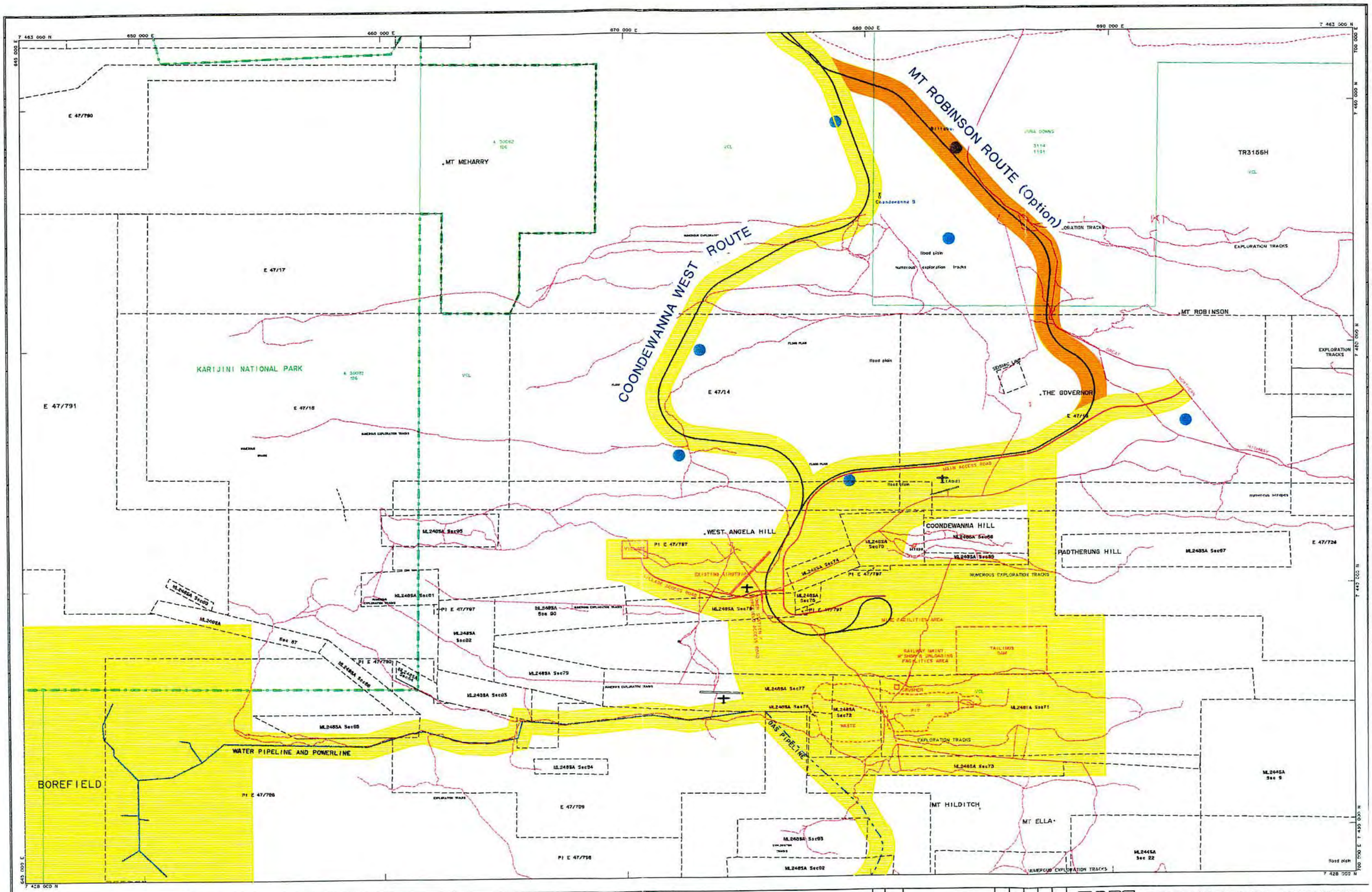
Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 324581, April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG	CONSULT	CLIENT
3	16/12/97	DEVELOPMENT LOCATIONS REVISED	RC	PB			
2	8/7/97	NATIONAL PARK BOUNDARY REVISED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE: 1 : 150 000 — DRAWN BY: AAM — DATE: 7/5/97
FILE No.: 324581 — DESIGNED BY: AAM — DATE: 7/5/97
DRAWING No.: 324538-9 — REV.: 3



LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
- ROAD (SEALED)
- ROAD (UNSEALED)
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- ROAD : PROPOSED
- RAILWAY
- RAILWAY : PROPOSED
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- GAS PIPELINE : PROPOSED
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- POWERLINE : PROPOSED
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SHEET INDEX

1 2 3 4 5 6 7 8 9 10 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97
Rail Locations	DXD	5480/01/01	Digital	1996
Quarry / Borrow sites	Soil & Rock	4188-1.0	Report	1997
Water Sources	ROCKWATER	242.0/97/1	Report	1997

SOURCE DATA	Source	Ref No	Medium	Date
Gas Pipelines	CMPS & F	0401	Graphical	1994
Mine Layout	RRIA	SK7695	Graphical	MAY 1996
Mine Services	C/Wagner	SK9387	Digital	1998

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

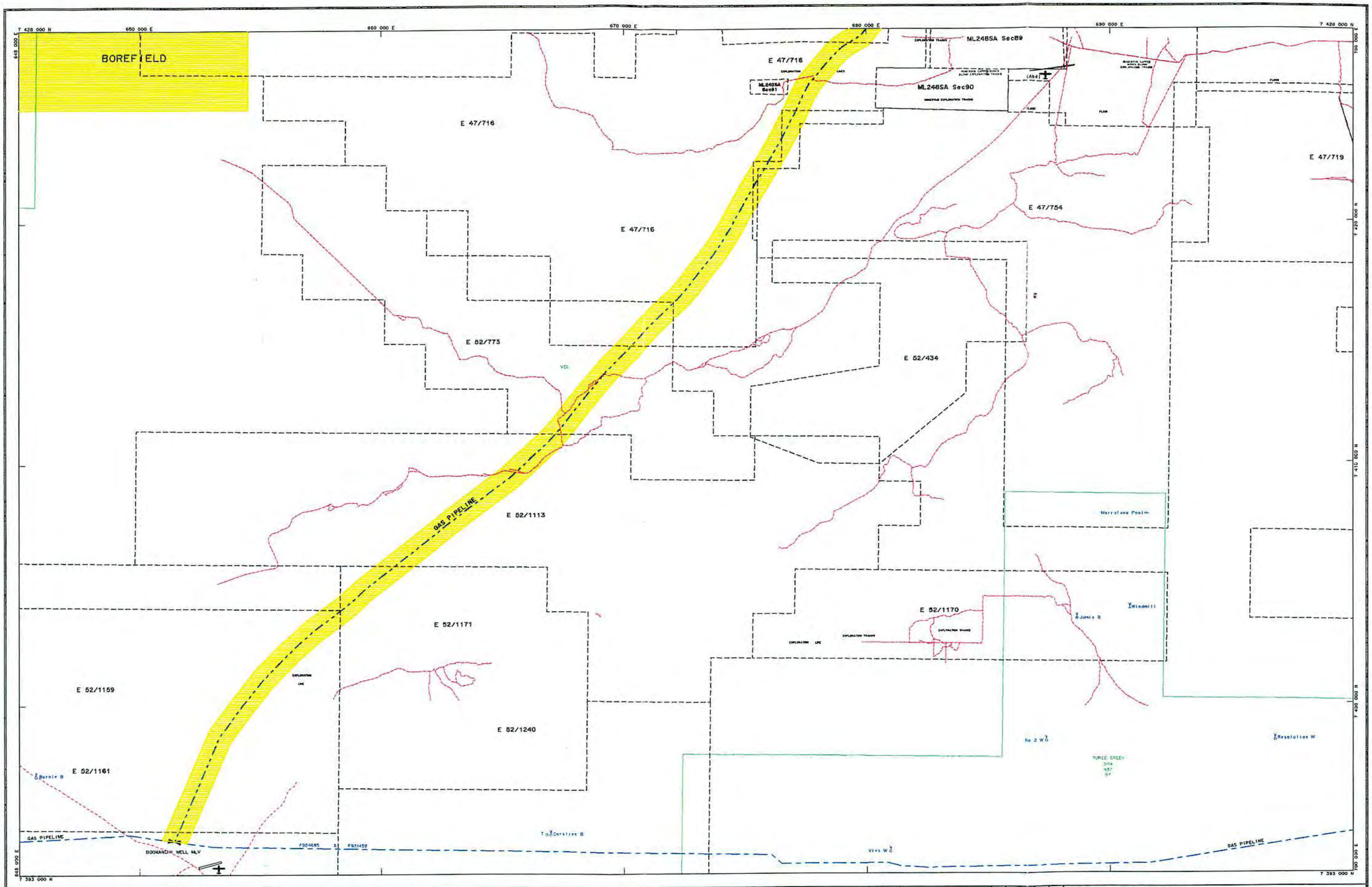
Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES AAM Surveys Ref: 324581 April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST. ENG.	CLIENT
4	16/2/98	DEVELOPMENT LOCATIONS REVISED	WC	PB			
3	8/7/97	NATIONAL PARK BOUNDARY REVISED	RC	PB			
2	19/5/97	ADDED OR3 ROUTE	RM	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE:	DRAWN BY:	DATE:
1 : 150 000	AAM	7/5/97
FILE No: 324581	CHECKED BY: AAM	DATE: 7/5/97
DRAWING No: 324538-10		REV. 4



LEGEND

- DEVELOPMENT AREA
- CADASTRE : LAND ACT
- CADASTRE : MINING ACT
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- ROAD (UNSEALED)
- TRACK
- ROAD : PROPOSED
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- GAS PIPELINE : PROPOSED
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- CONSTRUCTION CAMP

SHEET INDEX: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12

METADATA

SOURCE DATA	Source	Ref No	Medium	Date	SOURCE DATA	Source	Ref No	Medium	Date
Cadastre : Land	DOLA	DOLA.DGN	Digital	MAR 97	Gas Pipelines	CMPS & F	0401	Graphical	1994
Cadastre : Mining	DOME	TOPO.DGN	Digital	MAR 97	Mine Layout	RRIA	SKP895	Graphical	MAY 1996
Cultural Detail	DOME	TOPO.DGN	Digital	MAR 97	Mine Services	C/Wagner	SKP387	Digital	1998
Rail Locations	GHD	5480/01/01	Digital	1998					
Quarry / Borrow sites	Soil & Rock	4188-1.0	Report	1997					
Water Sources	ROCKWATER	242.0/97/1	Report	1997					

INTENDED USE : Project Definition

LIMITATIONS : Locations of intended facilities shown are subject to change

SCALE 1 0 1 2km

Compiled by AAM Surveys Pty Limited for ROBE RIVER IRON ASSOCIATES. AAM Surveys Ref. 334681. April 97

REV.	DATE	REVISION DETAILS	DRN	CHKD	ENG.	CONST ENG.	CLIENT
2	14/2/98	DEVELOPMENT LOCATIONS REVISED	RC	PB			
1	7/5/97	ISSUED	RC	PB			
0	17/4/97	ISSUED	RC	PB			

ROBE RIVER IRON ASSOCIATES

WEST ANGELAS IRON ORE DEVELOPMENT PROJECT DEFINITION

SCALE	DRAWN BY	DATE
1 : 150 000	AAM	7/5/97
FILE No 324581	CHECKED BY AAM	DATE 7/5/97
DRAWING No 324538-12		REV 2

APPENDIX C

Vegetation maps of the West Angelas Project Area

507 000E

7 660 000N

Millstream Chichester NP

Dampier

Pannawonica Cape Lambert Rlwy

Paraburdoo Rlwy

WR 19

WR18

WR17

WR 16

WR15

WR14

WR13

WR12

WR11

WR10

WRFL

WR9

WR8

WR7

WR6

WR5

WR4

WR3

WR2

WR1

A

A

Dampier Paraburdoo Rlwy

Wittenoom Roebourne Rd

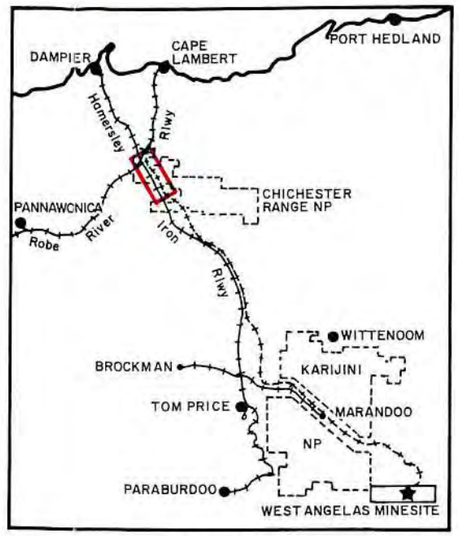
7 632 000N

513 000E

N

0 2 4km

Scale 1:75,000



LOCATION MAP

■ WR1 Fauna survey site

● Flora survey site

MAJOR FLOWLINES AND CREEKS

Floodplain: Scattered *Corymbia hamersleyana* over *Acacia tumida/Petalostylis labicheoides/Stylobasium spathulatum* shrubland over *Triodia wiseana* hummock grassland

Major flowline: Open *Eucalyptus victrix* woodland over tall *Acacia trachycarpa, A. coriacea* and *A. arida* over *Triodia pungens*

Major flowline: Scattered *Acacia bivenosa* shrubs over *Triodia pungens* hummock grassland

Major flowline: Open *Eucalyptus camaldulensis* woodland over tall *Acacia trachycarpa, A. coriacea* and *A. arida* over *Triodia pungens*

Major flowline: Scattered *Eucalyptus camaldulensis* and *Terminalia canescens* trees over *Cyperus vaginatus* sedge

Major flowline (permanent pools) Open *Melaleuca argentea* woodland over tall *Acacia trachycarpa, A. coriacea* and *A. arida* over *Triodia pungens*

Side channels and embankments: *Triodia pungens* hummock grassland

Creek: Open *Terminalia canescens* woodland over open *Acacia arida* shrubland over *Triodia wiseana* hummock grassland

Travertine deposits: *Acacia arida* shrubland over *Triodia wiseana/T. angusta* hummock grassland

Major flowlines (permanent seeps): Herbfields of annual species dominated by *Sesbania cannabina, Ammannia auriculata* and *Ludwigia perennis*

VOLCANIC FORMATIONS AND THEIR DERIVATIVES

Sloping flowline through low rise: Scattered *Corymbia hamersleyana* over open *Acacia tumida* and low *Cajanus cinereus* shrubland over *Triodia wiseana/T. pungens*

Cracking clay pockets: Mixed open herbland/grassland of Asteraceae, Convolvulaceae, Papilionaceae, Malvaceae and Poaceae species

Gentle slopes/basalt rises: Scattered *Acacia pyrifolia* over scattered *Indigofera monophylla/Hibiscus sturtii* shrubs and *Triodia wiseana* hummock grassland

Gentle/lower slopes: Scattered *Acacia pyrifolia* over scattered *Indigofera monophylla/Hibiscus sturtii* shrubs and *Triodia longiceps* hummock grassland

Undulating with cracking clay: *Eriachne benthamii/Bothriochloa* spp. tussock grassland with mixed herbs and annual grasses

Gentle slopes with slight relief: *Astrebla* spp. tussock grassland

LYRE CREEK AGGLOMERATE MEMBER

Gentle slopes: Scattered tall *Acacia arida* shrubs over *Triodia wiseana* hummock grassland

Small creek: Open *Acacia arida* shrubland over *Triodia pungens* hummock grassland

Low rise: Scattered tall *Acacia ancistrocarpa* over *Triodia wiseana* hummock grassland

Creek: Open *Acacia ancistrocarpa/A. arida/A. tumida* scrub over scattered low *Cajanus cinereus* shrubs and scattered *Triodia wiseana*

IRON BEARING FORMATIONS

Medium sized creek: Scattered tall *Acacia arida, A. pyrifolia* and *Flueggia virosa* over *Triodia wiseana* and *Eriachne tenuiculmis*

Minor flowline/lower slope: Scattered *Eucalyptus leucophloia* over *Acacia monticola* shrubland and scattered *Indigofera monophylla* over *Triodia wiseana*

Flat surface of remnant plateau: Scattered *Eucalyptus leucophloia* over scattered *Acacia bivenosa, Senna glutinosa* subsp. *glutinosa* and *Indigofera monophylla* over *Triodia wiseana/T. brizoides* hummock grassland

Flat surface of remnant plateau: Scattered *Acacia inaequilatera* and *Acacia bivenosa* over *Indigofera monophylla* and *Triodia wiseana* hummock grassland

Erosional spurs: Scattered *Corymbia hamersleyana* over *Acacia bivenosa, A. pyrifolia* and *A. holosericea* over *Triodia wiseana* hummock grassland

Broad upper slope flowlines on rises and spurs: Open *Eucalyptus leucophloia* woodland over *Acacia monticola* and/or *A. maitlandii* shrubland over *Triodia pungens*

Well defined creeks: Tall open *Acacia tumida* shrubland over *Petalostylis labicheoides* shrubland

Vegetation of the Hamersley Iron Parallel (Western) Rail Corridor

Vegetation mapping by N Casson & ME Trudgen

7 634 000N

Wittenoom Roebourne Rd

517 000E

MH1

A

ML2

ML3

ML1

547 000E

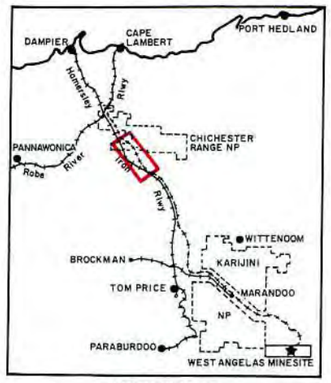
7 603 000N

Wittenoom Roebourne Rd

Millstream Chichester NP

Dampier Paraburdoo Rlwy

A



LOCATION MAP

MAJOR FLOWLINES AND CREEKS

Floodplain: Scattered *Corymbia hamersleyana* over *Acacia tumida/Petalostylis labicheoides/Stylobasium spathulatum* shrubland over *Triodia wiseana*

Major flowline: *Eucalyptus camaldulensis/Eucalyptus victrix* woodland over open *Acacia ancistrocarpa/A. tumida/Gossypium robinsonii* shrubland over *Themeda, Chrysopogon* and *Dichanthium* species

Major flowline (gravel pools): Open *Eucalyptus victrix* woodland over *Eriachne* spp. grasses and *Cyperus* spp. sedges

Major flowlines (clay patches and fringes): Tall *Acacia farnesiana* and *Melaleuca* spp. shrubland over low *Sida fibulifera* shrubland over sparse *Schoenoplectus* spp. sedgeland with scattered herbs and *Setaria* spp. grasses

Major flowline: *Eucalyptus victrix* woodland over tall *Acacia bivenosa/A. tumida/A. ancistrocarpa/Grevillea wickhamii* shrubland over *Triodia longiceps/T. wiseana/T. pungens* hummock grassland with scattered *Themeda* spp.

Floodplain of narrow channel: Open *Eucalyptus leucophloia* woodland over scattered *Acacia bivenosa* shrubs over scattered *Triodia pungens* and *Themeda* spp. in open *Paraneurachne muelleri* tussock grassland

Major flowline (calcrete area): *Eucalyptus victrix* woodland with scattered *Terminalia canescens* trees over open *Cyperus vaginatus* sedgeland

VOLCANIC FORMATIONS AND THEIR DERIVATIVES

Sloping flowline through low rise (some clay): Open *Acacia tumida* shrubland over low *Cajanus cinereus* shrubland and scattered *Triodia pungens*

Sloping flowline through low rise: Scattered *Corymbia hamersleyana* over open *Acacia tumida* and low *Cajanus cinereus* shrubland over *Triodia wiseana/T. pungens*

Diffuse, undulating upper drainage: Scattered *Corymbia hamersleyana* over scattered *Acacia pyrifolia/Grevillea pyramidalis* shrubs and *Triodia wiseana*

Sloping flowline in low rise: Open *Corymbia hamersleyana* woodland over *Triodia pungens*

Sloping flowline through low rise: Scattered *Corymbia hamersleyana* over open low *Cajanus cinereus* shrubland over *Triodia longiceps/T. wiseana/T. pungens*

Cracking clay pockets: Mixed open herbland/grassland of Asteraceae, Convolvulaceae, Papilionaceae, Malvaceae and Poaceae species

Gentle slopes/basalt rises: Scattered *Acacia pyrifolia* over scattered *Indigofera monophylla/Hibiscus sturtii* shrubs and *Triodia wiseana* hummock grassland

Gentle/lower slopes: Scattered *Acacia pyrifolia* over scattered *Indigofera monophylla/Hibiscus sturtii* shrubs and *Triodia longiceps* hummock grassland

Undulating with cracking clay: *Eriachne benthamii/Bothriochloa* spp. tussock grassland with mixed herbs and annual grasses

Gentle slopes with slight relief: *Astrebla* spp. tussock grassland

IRON BEARING FORMATIONS

Edge of flat-topped hill: Scattered *Eucalyptus leucophloia* over *Acacia maitlandii* shrubland

Flat surface of remnant plateau: Scattered *Eucalyptus leucophloia* over scattered *Acacia maitlandii* over *Triodia wiseana*

Flat surface of remnant plateau: Open *Eucalyptus leucophloia* woodland over scattered *Acacia maitlandii* shrubs over *Triodia brizoides/T. wiseana*

Flat surface of remnant plateau: Scattered *Eucalyptus leucophloia* over scattered *Acacia maitlandii* over *Triodia pungens/T. wiseana*

Upper slope flowline: Scattered *Acacia ancistrocarpa* over *Triodia wiseana*

Erosional spur: Tall *Acacia xiphophylla* shrubland over *Triodia brizoides*

Erosional spur Scattered *Acacia xiphophylla* over *Triodia wiseana*

Erosional spur: Scattered *Eucalyptus leucophloia* over *Triodia longiceps*

Erosional spurs: *Melaleuca eleuterostachya/Acacia bivenosa* shrubland over *Triodia longiceps/T. wiseana*

Broad upper slope flowlines on rises and spurs: Open *Eucalyptus leucophloia* woodland over *Acacia monticola* and/or *A. maitlandii* shrubland over *Triodia pungens*

Erosional spurs: Scattered *Eucalyptus leucophloia* over *Triodia pungens*

Well defined creeks passing through upper slope flowlines: Open *Acacia tumida* shrubland over *Petalostylis labicheoides* shrubland

Sloping flowline through low rise (some clay): Open *Acacia tumida* with scattered *Acacia bivenosa, A. maitlandii, A. ancistrocarpa* and *Petalostylis labicheoides* over low *Cajanus cinereus* shrubland and *Triodia pungens*

LOW FOOTHILLS AND ESCARPMENTS

Rounded low rise: Scattered *Acacia bivenosa/A.* sp. 15651/*Senna glutinosa* subsp. *glutinosa* over *Triodia wiseana* or;
Patches of *Eucalyptus leucophloia/Corymbia hamersleyana* over scattered *Acacia ancistrocarpa* over *Triodia pungens* and *Amphipogon caricinus*

Gentle slopes: *Acacia bivenosa/A. victoriae* over *Triodia brizoides/T. wiseana* with scattered *Paraneurachne muelleri*

Crests: *Triodia brizoides* hummock grassland

Gentle slopes: Tall *Acacia xiphophylla* over scattered *Triodia longiceps*

Depression/swale: Low open *Rhynchosia* spp. shrubland over *Triodia longiceps*

ML1 **Fauna survey site**

Flora survey site

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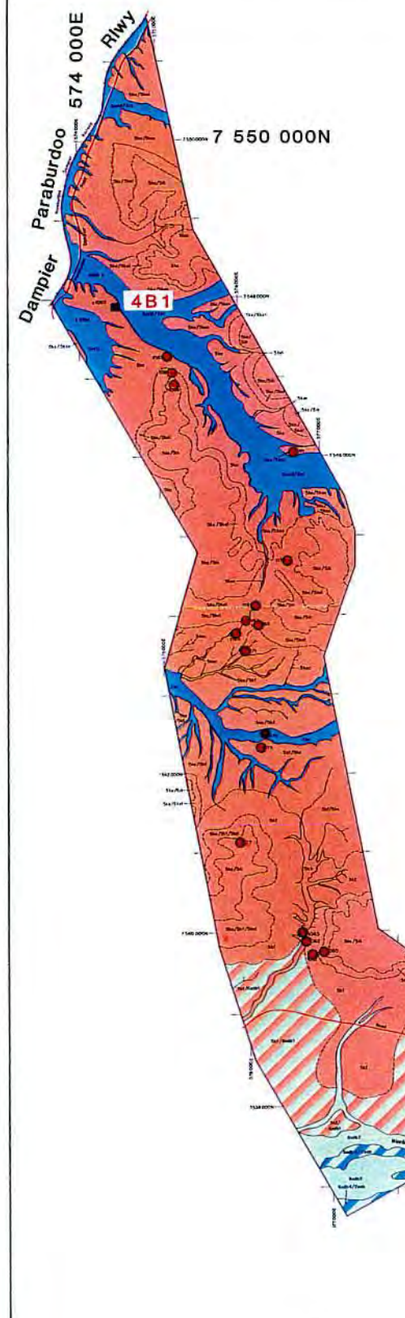
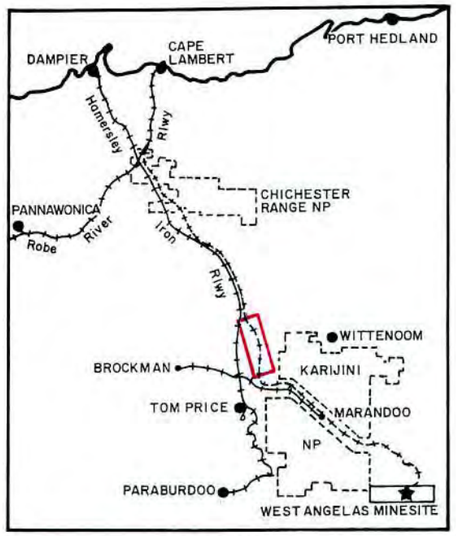
Scale 1:75,000

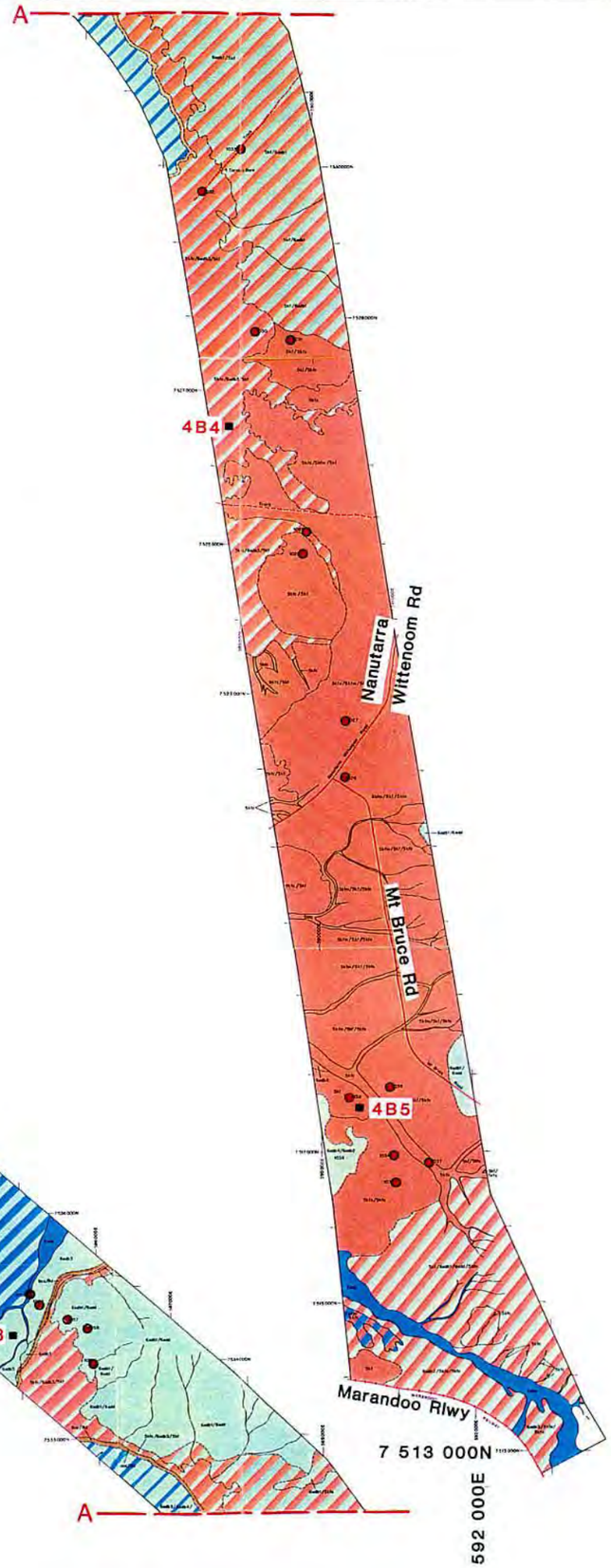
Vegetation of the Mt Leal Rail Corridor

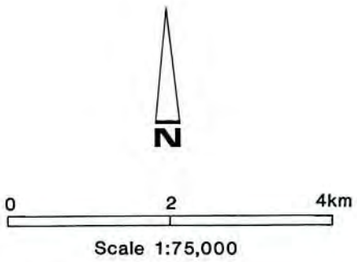
Vegetation mapping by N Casson & ME Trudgen





LOCATION MAP





MAJOR FLOWLINES AND CREEKS

Intermediate flowline: Open *Corymbia hamersleyana* woodland over tall *Acacia tumida* shrubland over scattered low *Tephrosia rosea* var. *glabra* shrubs over *Triodia pungens//T. wiseana* hummock grassland

Major flowline: *Triodia pungens* hummock grassland

Small flowline in cracking clay plains: *Eriachne benthamii* tussock grassland

Side channels and embankments: *Triodia pungens* hummock grassland

Floodplain of minor flowline: *Eucalyptus victrix/Acacia aneura/A. citrinoviridis* woodland over *Cenchrus ciliaris* tussock grassland

IRON BEARING FORMATIONS

Upper flowlines from remnant plateau: Scattered *Corymbia hamersleyana/Eucalyptus leucophloia* over scattered shrubs of *Acacia bivenosa,, Senna glutinosa* subsp. *glutinosa* and *Indigofera monophylla* over *Triodia pungens*

Crest/upper slope: Open *Eucalyptus leucophloia* woodland over scattered *Hakea chordophylla* and *Acacia maitlandii* over scattered low shrubs and *Triodia wiseana* hummock grassland

Spurs: Open *Corymbia deserticola/C. hamersleyana/Eucalyptus leucophloia* woodland over *Triodia wiseana* hummock grassland

Mid-slope flowline: Open *Corymbia hamersleyana* woodland over *Acacia monticola* shrubland over *Indigofera monophylla* shrubs and *Triodia wiseana* hummock grassland

Lower slope/embankment: Open *Corymbia hamersleyana* woodland over open *Acacia pyrifolia* and scattered low *Tephrosia rosea* var. *glabra* over *Triodia pungens*

Cliff bases: Open *Eucalyptus leucophloia* woodland over *Triodia wiseana* hummock grassland

Lower slope near creek/calcrete rises: *Eucalyptus leucophloia/Corymbia hamersleyana/Acacia aneura/A. pruinocarpa* woodland over *A. ancistrocarpa/A. pyrifolia/Senna glutinosa* shrubland over *Triodia wiseana*

Minor valley flowline: *Corymbia hamersleyana/Acacia aneura* woodland over scattered *Senna pruinosa* subsp. *helmsii* shrubs over *Triodia wiseana*

Lower slope near creek/calcrete rises: *Corymbia hamersleyana/Acacia aneura/A. pruinocarpa* woodland over *A. ancistrocarpa/A. pyrifolia/Senna glutinosa* shrubland over *Triodia wiseana*

Lower slope near creek/calcrete rises: *Eucalyptus leucophloia/Corymbia hamersleyana/Acacia aneura/A. pruinocarpa* woodland over *A. ancistrocarpa/A. pyrifolia/Senna glutinosa* shrubland over *Plectrachne melvillei*

Lower slope near creek/calcrete rises: *Corymbia hamersleyana/Acacia aneura/A. pruinocarpa* woodland over *A. ancistrocarpa/A. pyrifolia/Senna glutinosa* shrubland over *Plectrachne melvillei*

LOW FOOTHILLS AND ESCARPMENTS

Colluvial fan off low ridge: Open *Eucalyptus xerothermica/Acacia aneura/A. pruinocarpa* woodland over scattered *A. bivenosa* over *Triodia wiseana*

Flat to gentle slope with cracking clay and stones: Open *Eucalyptus xerothermica/Acacia pruinocarpa* woodland over scattered *Hakea suberea* over *Aristida latifolia/Chrysopogon fallax* tussock grassland

Flat to gentle slope: Scattered *Acacia aneura* trees over *Aristida latifolia/Chrysopogon fallax* tussock grassland

Flat to gentle slope: *Themeda* sp. blue tussock grassland

Mid-slope/low ridge: Scattered tall *Acacia xiphophylla* shrubs over *Triodia wiseana*

VOLCANIC FORMATIONS AND THEIR DERIVATIVES

Wide cracking clay plain: *Eriachne benthamii* tussock grassland

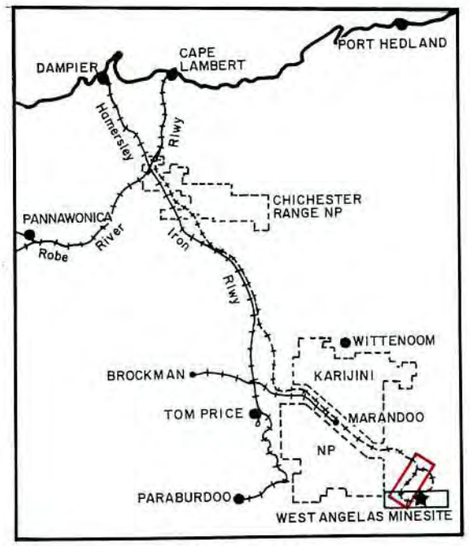
Gentle slopes with slight relief: *Astrebla* species tussock grassland

■ 4B1 **Fauna survey site**

● **Flora survey site**

Vegetation of the 4 Corners Bore Rail Corridor

Vegetation mapping by N Casson & ME Trudgen



LOCATION MAP

Vegetation mapping by
N Casson & ME Trudgen

BROCKMAN IRON FORMATION

Open *Eucalyptus leucophloia/Acacia pruinocarpa* woodland over open *A. bivenosa* shrubland over mosaic hummock grassland of *Triodia* aff. *basedowii*, *T. wiseana*, *T. pungens* and *Plectrachne melvillei*

Outcrops, breakaways and low cliffs: Open *Eucalyptus leucophloia/Acacia pruinocarpa* woodland over open *A. bivenosa* shrubland over *Triodia brizoides* hummock grassland

Banded iron detrital slopes/colluvial fans: Scattered *Corymbia deserticola* over scattered *Acacia bivenosa*, *A. pruinocarpa* and *Hakea chordophylla* over scattered *Cassia pruinosa* over *Triodia pungens/T.* aff. *basedowii* hummock grassland

Broad colluvial flowlines and channels: Scattered *Eucalyptus gamophylla* over tall scattered *Acacia bivenosa* over open Triodia *pungens/T. longiceps* hummock grassland

Midslope - lowerslope colluvial fans: Mixed tall open *Acacia* spp shrubland over low scattered *Maireana* spp. over very open *Triodia pungens* hummock grassland

Low ridges and steep slopes - Tall open *Acacia* aff. *aneura/ A.* aff. *catenulata* shrubland over mosaics of *Triodia wiseana*, *T.* aff. *basedowii* and *T. pungens* over scattered *Eriachne mucronata*

Hilltops, breakaways, slopes, spurs (minor dolomite): Tall open *Acacia* aff. *ayersiana/A. minyura* ms shrubland over open *Ptilotus obovatus/Scaevola* spp. shrubland over open *Triodia pungens* with scattered *Eriachne mucronata* tussock grass

Midslope/upperslope ridges: Scattered *Eucalyptus leucophloia*, *E. kingsmillii*, *E. trivalvis*, *E. pilbarensis* and *Corymbia hamersleyana* over scattered tall *Acacia rhodophloia/A. pruinocarpa* shrubs over *Ptilotus obovatus* over *Triodia wiseana/T. pungens* hummock grassland

Steep slopes and breakaways: Open *Corymbia deserticola/ Eucalyptus leucophloia* woodland over *Cassia pruinosa/Ptilotus obovatus* shrubland over *Triodia wiseana* with scattered *Cymbopogon* sp. and *Eriachne mucronata* tussock grasses

Steep slopes and spurs: Open *Eucalyptus leucophloia* woodland over tall *Acacia* aff. *aneura/A.* aff. *catenulata* shrubland over scattered *Cassia helmsii*, *Maireana* sp. and *Vittadinia* sp. over *Triodia pungens*

Upperslope of spur: *Eucalyptus striaticalyx* woodland over scattered *Cassia glutinosa* shrubs over *Maireana georgei* and open Triodia *longiceps* hummock grassland

Upperslope ridge: Open *Eucalyptus leucophloia* woodland over scattered *Acacia pruinocarpa* over open *Triodia pungens* hummock grassland

Steep spurs with siliceous outcrop: Open *Eucalyptus leucophloia* woodland over open *Triodia wiseana* hummock grassland with scattered *Eriachne mucronata* tussock grass

MARRAMAMBA IRON FORMATION

Colluvial lowerslopes: Scattered *Eucalyptus leucophloia* over open *Triodia* aff. *basedowii/T. pungens* hummock grassland

Crests, ridges, spurs and mid to upper slopes: Open *Eucalyptus leucophloia/Corymbia hamersleyana* woodland over scattered *Acacia maitlandii* over open *Triodia wiseana*

Slopes and crests of gullies and spurs and associated minor flowlines: Scattered *Eucalyptus leucophloia* and *Acacia pruinocarpa* over open *Triodia pungens* hummock grassland

Flowlines and floodbanks with gravel loam: *Corymbia hamersleyana* and *Eucalyptus xerothermica* over mixed open shrubland over *Triodia pungens* with open *Themeda triandra* and *Cymbopogon* sp. tussock grasses

Colluvial or alluvial fans with gravel loam: Open *Acacia pruinocarpa/A.* aff. *aneura/Acacia aneura* scrub over *Triodia pungens* hummock grassland

Gradual slopes, low hills and broad flowlines: Open *Acacia aneura/A.* aff. *aneura* scrub over open *Enneapogon* sp/*Dichanthium humilis* with scattered annual tussock grasses and *Bidens bipinnata*

Moderate to broad creeks and adjacent banks: Scattered tall *Acacia* aff. *aneura/ A. pruinocarpa* shrubs over scattered low *Maireana* spp. over *Triodia pungens* with scattered *Themeda triandra* tussock grass

Gradual slopes: Tall open *Acacia* aff. *aneura/A.* aff. *catenulata* shrubland over low scattered *Maireana* spp. over very open *Plectrachne melvillei* and scattered *Eriachne benthamii*

Mid-valley aolian/colluvial sheets of minor relief: Tall open Acacia *aneura/Acacia* aff. *aneura* shrubland over open *Triodia pungens*

Clay flood plains and claypans: Open *Eucalyptus victrix* woodland over Scattered *Acacia aneura* over *Enneapogon* sp./*Eriachne benthamii* tussock grassland with open *Eragrostis pergracilis* and *Aristida contorta* and *Marsilea* sp.

■ CW1 Fauna survey site

Flora survey site

VALLEYS, PLAINS & LOW FOOTHILLS

Flowlines and flood banks with gravel loam: *Corymbia hamersleyana/Eucalyptus xerothermica* woodland over mixed open shrubland over *Triodia pungens* hummock grassland with *Themeda triandra* and *Cymbopogon* sp.

Colluvial or alluvial fans with gravel loam: Open *Acacia aneura/A. pruinocarpa* scrub over *Triodia pungens*

Low rises and gradual slopes: Scattered *Corymbia deserticola* subsp. *deserticola* over open *Acacia aneura* scrub and scattered *Eremophila forrestii* over *Triodia pungens* or *Plectrachne melvillei* hummock grassland with mixed annual grasses and *Ptilotus helipteroides*

Gradual slopes, low hills and broad flowlines: Open *Acacia aneura* scrub over *Enneapogon* sp. and *Dichanthium humilis* tussock grassland with scattered annual grasses and *Bidens bipinnata*

Gradual slopes: Tall *Acacia aneura/A.* aff. *catenulata* shrubland over scattered *Rhagodia* sp. Hamersley and low *Maireana* sp. shrubs

Gradual slopes: Tall *Acacia aneura/Grevillea* sp. shrubland over over scattered *Rhagodia* sp. Hamersley and low *Maireana* sp./*Sida calyxhymenia* shrubs over *Triodia pungens* hummock grassland with scattered *Themeda triandra* tussock grass

Gradual slopes: Tall *Acacia aneura* shrubland over scattered *Rhagodia* sp. Hamersley and low *Maireana* sp. shrubs

Moderate to broad creeks and adjacent banks: Scattered tall *Acacia* aff. aneura/*A. pruinocarpa* shrubs over open *Triodia pungens* with scattered *Themeda triandra* hummock grass

Gradual slopes, low hills and broad flowlines: Open *Acacia* aff. *aneura* scrub over *Enneapogon* sp. and *Dichanthium humilis* tussock grassland with scattered annual grasses and *Bidens bipinnata*

Gradual slopes: Tall open *Acacia* aff. *aneura /A.* aff. *catenulata shrubland* over scattered low *Maireana* sp. shrubs over *Plectrachne melvillei* hummock grassland with scattered *Eriachne benthamii*

Gradual slopes and flats of valleys: Tall *Acacia* spp. shrubland over scattered *Plectrachne melvillei/Triodia pungens* hummock grassland

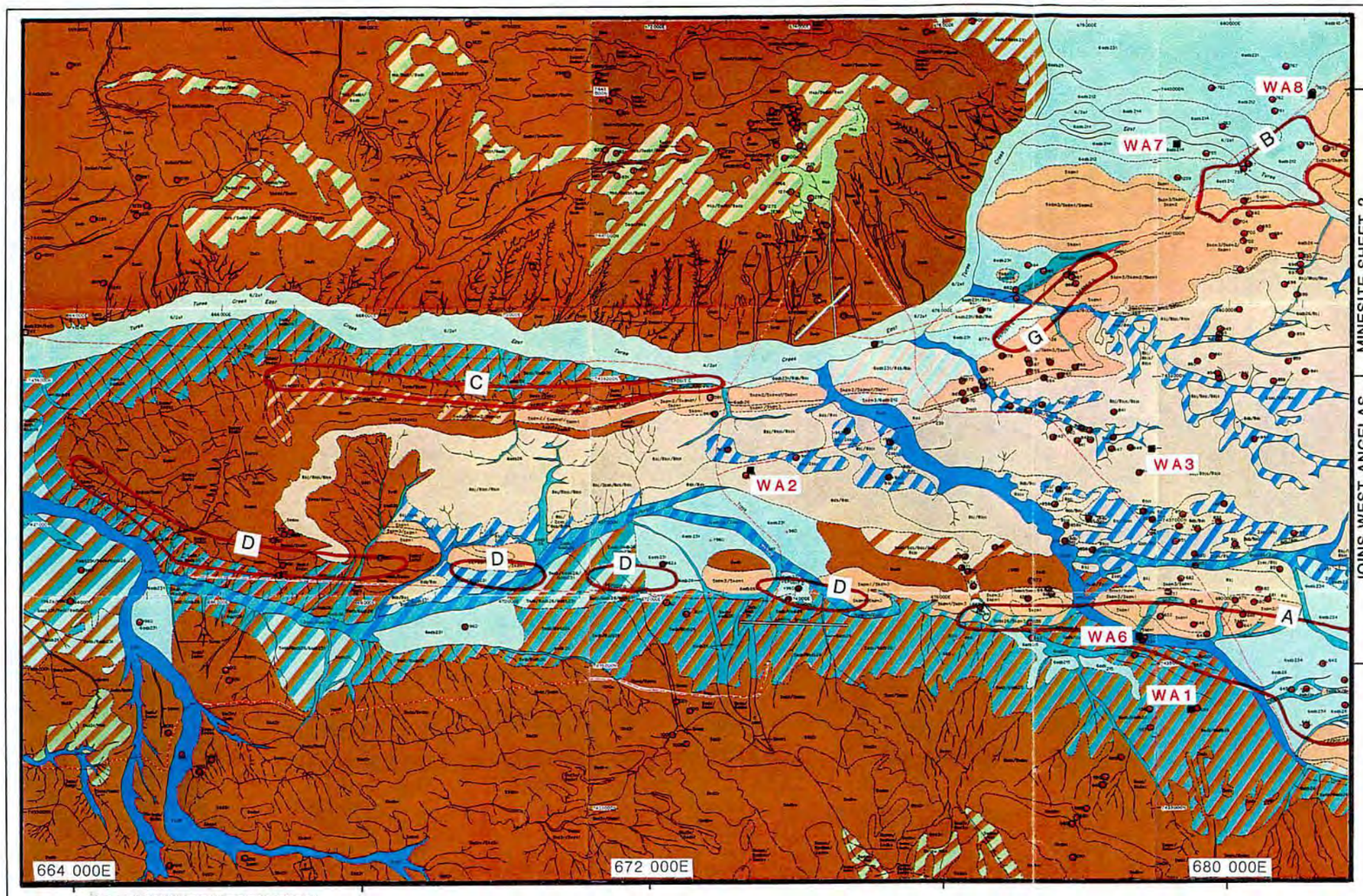
Mid-valley aeolian/colluvial sheets of minor relief: Tall *Acacia aneura/Acacia* aff. *aneura* shrubland over open *Triodia pungens* hummock grassland

Gradual slopes or flats: Tall *Acacia aneura* shrubland over open *Rhagodia* sp. Hamersley and *Ptilotus obovatus* shrubland over scattered *Digitaria brownii* tussock grassland

MAJOR FLOWLINES

Flowline: Low *Eucalyptus victrix* woodland over *Acacia ampliceps* over *Cyperus vaginatus* sedgeland

Vegetation of the Coondewanna West Rail Corridor



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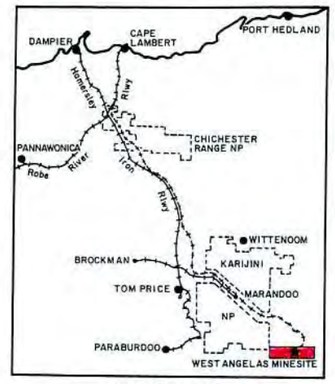
■ WA2 Fauna survey site

Flora survey site



LOCATION MAP

BROCKMAN IRON FORMATION

(i) Scattered *Eucalyptus gamophylla* over scattered tall shrubs, particularly *Acacia bivenosa*, over *Triodia pungens*
(ii) Open *Eucalyptus leucophloia* woodland over scattered tall *Acacia* spp. and open *Triodia pungens* or *T. wiseana*
(iii) Scattered *Corymbia deserticola* over sparse to open *Acacia* spp. over *Triodia pungens/T.* aff. *basedowii*
(iv) Open *Corymbia ferriticola* ssp. *ferriticola* woodland over open *Acacia aneura/A. pruinocarpa* shrubland and *Triodia pungens/Plectrachne melvillei*
(v) Scattered low *Eucalyptus* spp./*Corymbia hamersleyana* over scattered *Acacia pruinocarpa/A. rhodophloia* over *Triodia wiseana/T. pungens*
(vi) Tall open shrubland of *Acacia aneura, A. ayersiana* and *A.* aff. *catenulata* over open *Triodia pungens* or mixed *Triodia* spp.
(vii) Tall shrubland of *Acacia aneura, A. pruinocarpa* or *Acacia rhodophloia* over open *Triodia pungens* or *T. basedowii*
(viii) Tall open shrubland of *Acacia* aff. *ayersiana/A. minyura* ms over *Triodia pungens*
(ix) Open shrubland of *Scaevola acacioides* over *Triodia pungens*
(x) *Cyperus cunninghamii* and scattered herbs
(xi) Scattered trees of *Callitris columellaris*
(xii) Vertical cliffs with scattered low trees of *Ficus platypoda* var. *platypoda* over scattered shrubs of *Astrotricha hamptonii.*

MARRAMAMBA IRON FORMATION

(i) Low woodland of *Eucalyptus leucophloia/Corymbia ferriticola* over tall open *Acacia* spp. shrubland and *Triodia pungens* .
(ii) Low woodland of *Eucalyptus leucophloia/Corymbia hamersleyana* over scattered *Acacia maitlandii* and *Triodia wiseana*
(iii) Scattered *Eucalyptus leucophloia* over *Triodia pungens* with a tall shrubland of *Acacia* aff. catenulata sometimes present.
(iv) Scattered low *Eucalyptus gamophylla* over *Acacia hamersleyensis* over *Triodia pungens* or *Plectrachne* sp. Mt. Ella

MAJOR FLOWLINES

Scattered to open *Eucalyptus xerothermica* over *Acacia aneura* or *A. pruinocarpa* shrubs and open tussock/hummock grasslands of *Themeda triandra, Chrysopogon fallax, Triodia pungens* and *T. wiseana*

VALLEYS, PLAINS AND LOW FOOTHILLS

(i) Scattered *Corymbia hamersleyana* over tall shrubland of *Acacia aneura/A.* spp over *Triodia pungens*
(ii) Tall shrubland of *Acacia* spp. over *Tricdia pungens* and *Plectrachne melvillei*
(iii) Tall shrubland of *Acacia aneura* over open *Rhagodia* sp. Hamersley/*Ptilotus obovatus* over *Digitaria brownii* grassland
(iv) Tall open shrubland of *Acacia aneura* over open shrubland of *Eremophila forrestii* ssp. *forrestii/Rhagodia eremaea* over *Chrysopogon fallax*
(v) Tall open shrubland of *Acacia aneura/A. paraneura* over scattered low shrubs of *Eremophila lanceolata*
(vi) Open annual grassland of *Aristida contorta*

JEERINAH FORMATION

(i) Scattered *Eucalyptus camaldulensis* and *Acacia aneura* over *Triodia longiceps/T. wiseana*
(ii) Open *Eucalyptus socialis* woodland over tall *Acacia synchronicia* shrubland over *Triodia longiceps/T. wiseana*
(iii) Scattered shrubs of *Acacia pyrifolia* and *Eremophila fraserii* spp. *fraseri* over *Triodia wiseana*
(iv) Tall open shrubland of *Acacia aneura/A.* spp. over *Triodia pungens* or *T. pungens/T. wiseana.*
(v) Low scattered shrubs of *Chenopodium auricomum* over scattered *Eragrostis setifolia*
(iv) Low scattered shrubs of *Sida fibulifera* over *Astrebla squarrosa* tussock grassland
(vii) Open tussock grassland of *Astrebla pectinata, A. elymoides* and *Aristida latifolia*
(viii) *Triodia wiseana/T. brizoides* hummock grassland
(ix) Mixed tall *Acacia* spp. over open *Eremophila platycalyx* ssp. *pardalotta/Ptilotus obovatus* shrubland over *Triodia pungens.*

WITTENOOM FORMATION

Scattered *Acacia bivenosa/A. pyrifolia/A.* sp. (Site 1272) over *Triodia wiseana* hummock grassland.

Vegetation of the West Angelas Minesite

Sheet 1

Vegetation mapping by N Casson & ME Trudgen

JOINS WEST ANGELAS MINESITE SHEET 1

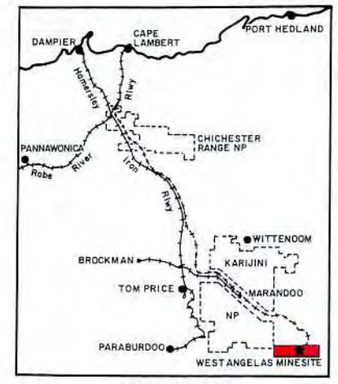
N

0 2 4km

Scale 1:75,000

■ WA4 Fauna survey site

Flora survey site



LOCATION MAP

BROCKMAN IRON FORMATION

(i) Scattered *Eucalyptus gamophylla* over scattered tall shrubs, particularly *Acacia bivenosa*, over *Triodia pungens*
(ii) Open *Eucalyptus leucophloia* woodland over scattered tall *Acacia* spp. and open *Triodia pungens* or *T. wiseana*
(iii) Scattered *Corymbia deserticola* over sparse to open *Acacia* spp. over *Triodia pungens/T.* aff. *basedowii*
(iv) Open *Corymbia ferriticola* ssp. *ferriticola* woodland over open *Acacia aneura/A. pruinocarpa* shrubland and *Triodia pungens/Plectrachne melvillei*
(v) Scattered low *Eucalyptus* spp./*Corymbia hamersleyana* over scattered *Acacia pruinocarpa/A. rhodophloia* over *Triodia wiseana/T. pungens*
(vi) Tall open shrubland of *Acacia aneura, A. ayersiana* and *A.* aff. *catenulata* over open *Triodia pungens* or mixed *Triodia* spp.
(vii) Tall shrubland of *Acacia aneura, A. pruinocarpa* or *Acacia rhodophloia* over open *Triodia pungens* or *T. basedowii*
(viii) Tall open shrubland of *Acacia* aff. *ayersiana/A. minyura* ms over *Triodia pungens*
(ix) Open shrubland of *Scaevola acacioides* over *Triodia pungens*
(x) *Cyperus cunninghamii* and scattered herbs
(xi) Scattered trees of *Callitris columellaris*
(xii) Vertical cliffs with scattered low trees of *Ficus platypoda* var. *platypoda* over scattered shrubs of *Astrotricha hamptonii*.

MARRAMAMBA IRON FORMATION

(i) Low woodland of *Eucalyptus leucophloia/Corymbia ferriticola* over tall open *Acacia* spp. shrubland and *Triodia pungens*
(ii) Low woodland of *Eucalyptus leucophloia/Corymbia hamersleyana* over scattered *Acacia maitlandii* and *Triodia wiseana*
(iii) Scattered *Eucalyptus leucophloia* over *Triodia pungens* with a tall shrubland of *Acacia* aff. catenulata sometimes present.
(iv) Scattered low *Eucalyptus gamophylla* over *Acacia hamersleyensis* over *Triodia pungens* or *Plectrachne* sp. Mt. Ella

MAJOR FLOWLINES

Scattered to open *Eucalyptus xerothermica* over *Acacia aneura* or *A. pruinocarpa* shrubs and open tussock/hummock grasslands of *Themeda triandra, Chrysopogon fallax, Triodia pungens* and *T. wiseana*

VALLEYS, PLAINS AND LOW FOOTHILLS

(i) Scattered *Corymbia hamersleyana* over tall shrubland of *Acacia aneura/A.* spp over *Triodia pungens*
(ii) Tall shrubland of *Acacia* spp. over *Triodia pungens* and *Plectrachne melvillei*
(iii) Tall shrubland of *Acacia aneura* over open *Rhagodia* sp. Hamersley/*Ptilotus obovatus* over *Digitaria brownii* grassland
(iv) Tall open shrubland of *Acacia aneura* over open shrubland of *Eremophila forrestii* ssp. *forrestii/Rhagodia eremaea* over *Chrysopogon fallax*
(v) Tall open shrubland of *Acacia aneura/A. paraneura* over scattered low shrubs of *Eremophila lanceolata*
(vi) Open annual grassland of *Aristida contorta*

JEERINAH FORMATION

(i) Scattered *Eucalyptus camaldulensis* and *Acacia aneura* over *Triodia longiceps/T. wiseana*
(ii) Open *Eucalyptus socialis* woodland over tall *Acacia synchronicia* shrubland over *Triodia longiceps/T. wiseana*
(iii) Scattered shrubs of *Acacia pyrifolia* and *Eremophila fraserii* ssp. *fraseri* over *Triodia wiseana*
(iv) Tall open shrubland of *Acacia aneura/A.* spp. over *Triodia pungens* or *T. pungens/T. wiseana.*
(v) Low scattered shrubs of *Chenopodium auricomum* over scattered *Eragrostis setifolia*
(iv) Low scattered shrubs of *Sida fibulifera* over *Astrebla squarrosa* tussock grassland
(vii) Open tussock grassland of *Astrebla pectinata, A. elymoides* and *Aristida latifolia*
(viii) *Triodia wiseana/T. brizoides* hummock grassland
(ix) Mixed tall *Acacia* spp. over open *Eremophila platycalyx* ssp. *pardalotta/Ptilotus obovatus* shrubland over *Triodia pungens.*

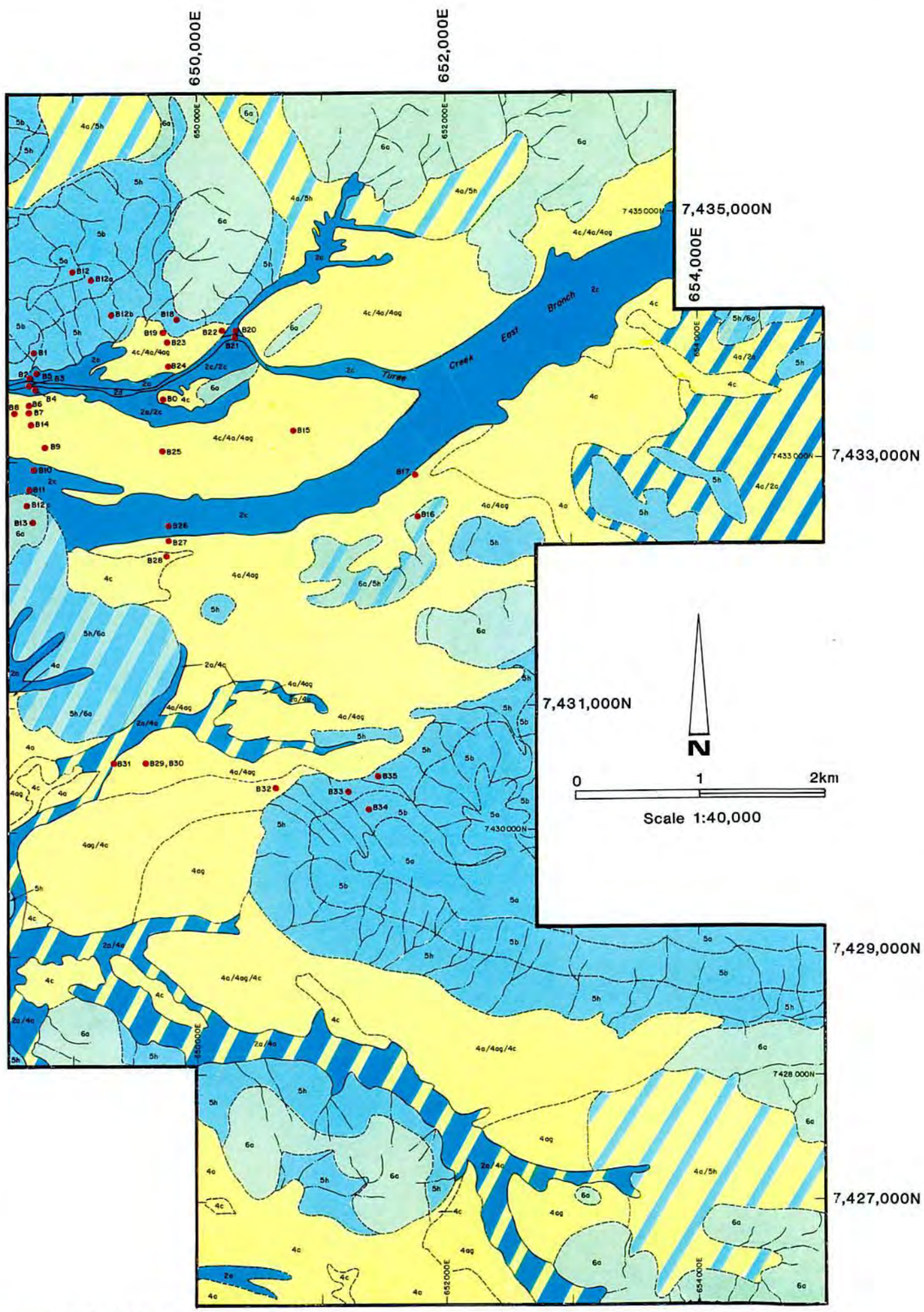
WITTENOOM FORMATION

Scattered *Acacia bivenosa/A. pyrifolia/A.* sp. (Site 1272) over *Triodia wiseana* hummock grassland.

Vegetation of the West Angelas Minesite

Sheet 2

Vegetation mapping by N Casson & ME Trudgen



MAJOR FLOWLINES AND CREEKS

Major flowline: Low woodland/shrubland of *Acacia aneura* over open *Triodia pungens*, *Enneapogon caerulescens*, *Aristida contorta* and *Ptilotus helipteroides*

Major flowline: Low *Acacia citrinoviridis* woodland over low *Ptilotus obovatus* shrubland over open annual tussock grassland

Channels and banks: Open *Eucalyptus victrix/Acacia citrinoviridis* woodland over *Acacia pyrifolia* open shrubland over open tussock grassland

MINOR CREEKS

Sloping, minor drainage lines: Scattered low trees of *Corymbia hamersleyana* and shrublands of *Acacia* spp

FLATS

Broad, level to gently sloping flats: Low open woodland/shrubland of *Acacia aneura* over annual tussock grassland of *Aristida contorta*

Broad, level to gently sloping flats: Open groves of *Acacia aneura/Acacia* spp. over *Eremophila forrestii* subsp. *forrestii* ms open shrubland over *Triodia pungens*, annual grasses and herbs

Broad, level to gently sloping flats: Scattered *Acacia aneura* shrubs over low Salsola *kali* shrubland over open herbs dominated by *Ptilotus aervoides*, *Lepidium phlebopetalum* and *Tragus austalianus*

MOUNTAIN RIDGES, SLOPES AND COLLUVIAL FANS

Upper slopes and ridges: Scattered *Eucalyptus leucophloia* and *Acacia aneura* over open shrubland of *Cassia glutinosa*, *Eremophila compacta* and *Ptilotus rotundifolius* over *Triodia pungens*, *Triodia* aff. *basedowii* and *Triodia wiseana*

Middle and lower slopes: Scattered tall shrubs of *Acacia aneura* over low open shrubland of Eremophila *forrestii* subsp. *forrestii* ms over *Triodia pungens*

Lower slopes and colluvial fans: *Acacia wanyu/Acacia* spp. shrubland over low heath of *Cassia 'stricta'* over *Triodia pungens*, *Aristida contorta* and *Eriachne pulchella* subsp. *pulchella*

LOW HILLS

Upper slopes and ridges: *Acacia aneura* high shrubland over *Cassia 'stricta'* low shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *pulchella* open annual tussock grassland and *Triodia pungens* hummock grassland

Flora survey site

Vegetation of the proposed borefield

Vegetation mapping by Dr AS Weston

APPENDIX D

Flora species list

Species list, Flora Surveys of Orebody A and Orebody B in the West Angela Hill area, an area surrounding them, and of rail route options considered to link them to the existing Robe River Iron Associates rail line

(Alphabetical by species)

Abelmoschus ficulneus
Abutilon aff. *fraseri* (site 1212)
Abutilon aff. *lepidum* (1) (MET 15,352)
Abutilon aff. *lepidum* (2) (MET 15,970)
Abutilon aff. *lepidum* (3) (MET 16 120)
Abutilon amplum
Abutilon cryptopetalum
Abutilon cunninghamii
Abutilon fraseri
Abutilon lepidioicum (MS)
Abutilon lepidum
Abutilon leucopetalum
Abutilon macrum
Abutilon malvifolium
Abutilon otocarpum
Abutilon oxycarpum ssp. *prostratum*
Abutilon sp.
Abutilon sp. (SD 083)
Abutilon sp. *A*
Abutilon sp. *B*
Abutilon sp. Pilbara (W.R. Barker 2025)
Abutilon sp. West Angela Hill (M.E. Trudgen 16,132)
Abutilon trudgenii (MS)
Acacia ?lysiphloia x monticola (B.R. Maslin 2671)
Acacia acradenia
Acacia adoxa var. *adoxa*
Acacia adsurgens
Acacia aff. *adsurgens* (1)
Acacia aff. *adsurgens* (2)
Acacia aff. *adsurgens* (3)
Acacia aff. *aneura* (grey, flat, recurved tips; MET 15,828)
Acacia aff. *aneura* (narrow, fine veined; site 1,259)
Acacia aff. *aneura* (narrow, green; MET 15,850)
Acacia aff. *aneura* (scythe-shaped; MET 15,743)
Acacia aff. *aneura* (subterete, long; site 1,245)
Acacia aff. *ayersiana* (MET 16,088)
Acacia aff. *ayersiana* (narrow form; MET 15,786)
Acacia aff. *catenulata*
Acacia aff. *citrinoviridis* (1)
Acacia aff. *inaequilatera* (little phyllode form)
Acacia aff. *inaequilatera* (MET 15,011)
Acacia aff. *minyura* (MS)
Acacia aff. *morrisonii* (site 1117)
Acacia aff. *stowardii* (linear form)
Acacia aff. *tumida*
Acacia ampliceps
Acacia ancistrocarpa
Acacia aneura (ASW a2a; thick medium terete)
Acacia aneura (flat, curved; MET 15,548)
Acacia aneura (grey bushy form; MET 15,732)
Acacia aneura (grey, flat, recurved tips; MET 15,828)
Acacia aneura (MET 15,742)
Acacia aneura (MET 15,748
Acacia aneura (sinuous; *ASW B6*)
Acacia aneura sens. lat.
Acacia aneura var. (green, flat; MET 15,946)
Acacia aneura var. *?*
Acacia aneura var. *?aneura*
Acacia aneura var. *?aneura/intermedia*
Acacia aneura var. aff. *longicarpa* (MET 16,050)
Acacia aneura var. *conifera*
Acacia aneura var. *longicarpa*
Acacia arida
Acacia atkinsiana
Acacia ayersiana
Acacia bivenosa
Acacia bivenosa (wispy form)
Acacia citrinoviridis
Acacia coriacea ssp. *pendens*
Acacia cowleana
Acacia dictyophleba
Acacia elachantha
Acacia eriopoda x monticola (B.R. Maslin 7322)
Acacia farnesiana
Acacia hamersleyensis (bushy form)
Acacia hamersleyensis (spindly form)
Acacia hilliana
Acacia holosericea
Acacia inaequilatera
Acacia inaequilatera (little phyllode form)
Acacia kempeana (1)
Acacia kempeana (2)
Acacia maitlandii
Acacia marramamba
Acacia minyura (MS)
Acacia monticola
Acacia morrisonii
Acacia orthocarpa
Acacia oswaldii
Acacia pachyacra
Acacia paraneura
Acacia pruinocarpa
Acacia pyrifolia
Acacia pyrifolia (bark not corky)
Acacia pyrifolia (slender form)
Acacia pyrifolia (stout form)
Acacia retivenea
Acacia rhodophloia
Acacia sclerosperma ssp. *sclerosperma*
Acacia sp.
Acacia sp. (MET 15,650)
Acacia sp. (site 1149)
Acacia sp. (site 1185)
Acacia sp. West Angelas (M.E. Trudgen 16,163)
Acacia sphaerostachya
Acacia stowardii
Acacia stowardii (linear form)
Acacia synchronicia
Acacia tenuissima
Acacia tetragonophylla
Acacia trachycarpa
Acacia translucens
Acacia tumida
Acacia validinervia
Acacia victoriae
Acacia wanyu
Acacia xiphophylla
*Achyranthes aspera**
Acrachne racemosa
Adriana tomentosa
*Aerva javanica**
Aeschynomene indica
Alectryon oleifolius ssp. *oleifolius*
Alternanthera angustifolia
Alternanthera nana
Alternanthera nodiflora
Alysicarpus muelleri
Alysicarpus rugosus
Amaranthus ?interruptus
Amaranthus aff. *mitchellii*
Amaranthus cf. *interruptus* (1)
Amaranthus cf. *interruptus* (2)
Amaranthus cf. *interruptus* (3) (MET 12, 524)
Amaranthus cf. *pallidiflorus* (1)
Amaranthus mitchellii
Amaranthus pallidiflorus
Amaranthus sp.
Ammannia auriculata

Ammannia baccifera
Amphipogon caricinus
Amyema benthamii
Amyema fitzgeraldii
Amyema gibberula var. *gibberula*
Amyema hilliana
Amyema miquelii
Amyema sanguinea var. *pulcher*
Amyema sp. aff. *bifurcata*
Andrachne decaisnei
Anthobolus leptomerioides
Aristida aff. *latifolia* (M. Lazarides 3524)
Aristida burbidgeae
Aristida contorta
Aristida holathera var. *holathera*
Aristida inaequiglumis
Aristida latifolia
Aristida lazaridis
Aristida obscura
Aristida sp.
Aristida sp. (MET 11,688)
Astrebla elymoides
Astrebla pectinata
Astrebla sp.
Astrotricha hamptonii
Atalaya hemiglauca
Basilicum polystachyon
Bergia pedicellaris
Bergia trimera
*Bidens bipinnata**
Blumea tenella
Boerhavia burbidgeana
Boerhavia coccinea
Boerhavia gardneri
Boerhavia paludosa
Boerhavia repleta
Boerhavia sp.
Bonamia media var. *villosa*
Bonamia pannosa
Bonamia rosea
Bothriochloa bladhii
Bothriochloa ewartiana
Brachyachne convergens
Brachyachne prostrata
Brachychiton acuminatus
Brachyscome ciliaris
Brachyscome iberidifolia
Bracteantha aff. *bracteata*
Brunonia australis
Bulbostylis barbata
Bulbostylis turbinata
Cajanus cinereus
Calandrinia balonensis
Calandrinia ptychosperma
Calandrinia quadrivalvis
Calandrinia schistorhiza
Calandrinia sp.
Calandrinia sp. (site 648)
Calandrinia sp. (sterile)
Calandrinia sp. Mt Bruce (MET 12,695)
Callitris columellaris
Calocephalus knappii
Calocephalus sp. Wittenoom (A.S. George 1082)
Calotis hispidula
Calotis plumulifera
Calytrix carinata
Canthium attenuatum
Canthium latifolium
Canthium suaveolens
Capparis lasiantha
Capparis mitchellii
Capparis spinosa var. *nummularia*
Capparis umbonata
Carissa lanceolata
Cassia 'glaucifolia'
Cassia 'stricta'
Cassia 'symonii'
Cassia ?'glaucifolia' x glutinosa
Cassia ?oligophylla x glutinosa
Cassia aff. *oligophylla* (thinly sericeous; MET 15,035)
Cassia aff. *pruinosa* (MET 15,687)
Cassia artemisioides
Cassia artemisioides (short leaflets)
Cassia chatelainiana
Cassia ferraria
Cassia glutinosa
Cassia glutinosa x 'stricta'
Cassia glutinosa x luerssenii
Cassia hamersleyensis
Cassia hamersleyensis x sp. Karajini (MET 10,392)
Cassia helmsii
Cassia helmsii x
Cassia luerssenii
Cassia luerssenii x 'stricta'
Cassia notabilis
Cassia oligophylla
Cassia oligophylla x
Cassia oligophylla x glutinosa
Cassia oligophylla x helmsii
Cassia pleurocarpa var. *pleurocarpa*
Cassia pruinosa
Cassia sp.
Cassia sp. aff. *'glaucifolia'* (site 888)
Cassia sp. Karajini (MET 10,392)
Cassia sp. Meekatharra (E. Bailey 1-26)
Cassia sp. West Angelas (MET 16,115)
Cassia sturtii
Cassia sturtii x?
Cassia venusta
Cassytha capillaris
Cassytha filiformis
*Cenchrus ciliaris**
*Cenchrus setigerus**
*Centaurium spicatum**
Chara sp.
Chara sp. (MET 15,208)
Cheilanthes austrotenuifolia
Cheilanthes lasiophylla
Cheilanthes sieberi ssp. *sieberi*
Chenopodium auricomum
Chenopodium melanocarpum ssp. *melanocarpum*
Chenopodium saxatile
Chloris pectinata
Chloris virgata
Chrysocephalum aff. *apiculatum*
Chrysocephalum aff. *semicalvum*
Chrysocephalum pterochaetum
Chrysocephalum semicalvum
Chrysopogon fallax
Citrullus aff. *lanatus**
*Citrullus colocynthis**
Cleome oxalidea
Cleome viscosa
Clerodendrum floribundum var. *angustifolium*
Clerodendrum sp.
Clerodendrum tomentosum var. *lanceolatum*
Codonocarpus cotinifolius
Commelina ensifolia
Convolvulus ?remotus
Convolvulus erubescens
Corchorus aestuans
Corchorus aff. *lasiocarpus* (MS) (A.A. Mitchell PRP 943)
Corchorus aff. *walcotti* (K.J. Atkins 570)
Corchorus crozophorifolius
Corchorus laniflorus
Corchorus lasiocarpus var. *lasiocarpus* (MS)
Corchorus lasiocarpus var. *parvus* (MS)
Corchorus parviflorus
Corchorus sidoides
Corchorus sp.
Corchorus sp. Hamersley
Corchorus sp. Millstream (A.S.George 3488)
Corchorus tridens
Corymbia aspera
Corymbia deserticola
Corymbia ferriticola ssp. *ferriticola*
Corymbia hamersleyana
Corymbia semiclara
Crassula peduncularis
Crotalaria benthamiana
Crotalaria cunninghamii
Crotalaria juncea
Crotalaria medicaginea
Crotalaria novae-hollandiae
Cryptandra monticola
Cucumis melo ssp. *agrestis*

*Cucumis myriocarpus**
Cullen aff. *lachnostachys* (MET 15,073)
Cullen cinereum
Cullen graveolens
Cullen lachnostachys
Cullen leucanthum
Cullen leucochaites
Cullen pogonocarpum
Cullen stipulaceum
Cuphantus andreanus
Cymbopogon ambiguus
Cymbopogon obtectus
Cymbopogon procerus
Cymbopogon sp.
Cynanchum aff. *floribundum* (MET 15,941)
Cynanchum floribundum
Cynanchum sp. (MET 15,151)
Cynanchum sp. 1(MET 2,302)
Cynanchum sp. Hamersley
*Cynodon dactylon**
Cyperus bifax
Cyperus blakeanus
Cyperus bulbosus
Cyperus cunninghamii ssp. *cunninghamii*
Cyperus dactylotes
Cyperus difformis
Cyperus hesperius
Cyperus iria
Cyperus squarrosus
Cyperus vaginatus
Dactyloctenium radulans
Dampiera candicans
Dampiera sp. Mt Meharry
Datura leichhardtii
Daucus glochidiatus
Desmodium aff. *campylocaulon*
Desmodium aff. *muellerii* (MET 15,346)
Desmodium campylocaulon
Desmodium muelleri
Desmodium sp.
Desmodium sp. (MET 16,191)
Dichanthium fecundum
Dichanthium sericeum ssp. *humilius*
Dichanthium sericeum ssp. *polystachyum*
Dichanthium sericeum ssp. *sericeum*
Dichrostachys spicata
Dicladanthera forrestii
Dicliptera armata
Digitaria aff. *ammophila*
Digitaria brownii
Digitaria ctenantha
Diplachne fusca
Diplatia grandibractea
Dipteracanthus australasicus ssp. *australasicus*
Dissocarpus paradoxus
Dodonaea coriacea
Dodonaea lanceolata var. *lanceolata*
Dodonaea pachyneura
Dodonaea viscosa ssp. *mucronata*
Dolichandrone heterophylla
Drosera indica
Dysphania glomulifera ssp. *eremaea*
Dysphania kalpari
Dysphania plantaginella
Dysphania rhadinostachya
Dysphania rhadinostachya ssp. *inflata*
Dysphania rhadinostachya ssp. *rhadinostachya*
*Echinochloa colona**
Ehretia saligna var *saligna*
Eleocharis atropurpurea
Eleocharis geniculata
Elytrophorus spicatus
Enchylaena tomentosa
Enchylaena tomentosa var. *?tomentosa*
Enneapogon aff. *clelandii* (Perth 00850667)
Enneapogon caerulescens var. *caerulescens*
Enneapogon caerulescens var. *occidentalis*
Enneapogon caerulescens var. *occidentalis* (large form; J.M. Bennett 68)
Enneapogon intermedius
Enneapogon oblongus
Enneapogon polyphyllus
Enneapogon sp.
Enteropogon acicularis
Eragrostis ?elongata
Eragrostis aff. *eriopoda*
Eragrostis crateriformis
Eragrostis cumingii
Eragrostis dielsii
Eragrostis eriopoda
Eragrostis exigua
Eragrostis leptocarpa
Eragrostis pergracilis
Eragrostis setifolia
Eragrostis sp.
Eragrostis sp. Mt Montagu (MET 15,246)
Eragrostis tenellula
Eremophila caespitosa
Eremophila clarkei
Eremophila cuneifolia
Eremophila exilifolia
Eremophila forrestii ssp. *forrestii* MS
Eremophila forrestii x latrobei
Eremophila fraseri ssp. *fraseri*
Eremophila hughesii ssp. *hughesii*
Eremophila jucunda ssp. *pulcherrima*
Eremophila lachnocalyx
Eremophila latrobei ssp. *filiformis*
Eremophila latrobei ssp. *glabra*
Eremophila longifolia
Eremophila macmillaniana
Eremophila magnifica
Eremophila oppositifolia ssp. *angustifolia*
Eremophila phyllopoda ssp. *obliqua*
Eremophila platycalyx ssp. *pardalota*
Eremophila platycalyx ssp. *platycalyx*
Eremophila sp.
Eremophila youngii ssp. *youngii*
Eriachne aff. *benthamii* (MET 12,752)
Eriachne aff. *mucronata* (fine species MET 12,737)
Eriachne aristidea
Eriachne benthamii
Eriachne ciliata
Eriachne flaccida
Eriachne helmsii
Eriachne lanata
Eriachne mucronata
Eriachne mucronata (arid form) (MET 12,736)
Eriachne mucronata (typical form)
Eriachne pulchella ssp. *dominii*
Eriachne pulchella ssp. *pulchella*
Eriachne sp. aff. *festucacea*
Eriachne tenuiculmis
Erodium cygnorum ssp. *cygnorum*
Erythrina vespertilio
Eucalyptus camaldulensis var. *obtusa*
Eucalyptus gamophylla
Eucalyptus kingsmillii
Eucalyptus leucophloia
Eucalyptus pilbarensis
Eucalyptus socialis
Eucalyptus striaticalyx
Eucalyptus trivalvis
Eucalyptus victrix
Eucalyptus xerothermica
Eulalia aurea
Euphorbia aff. *australis* var. 1 (MET 12,337)
Euphorbia aff. *australis* var. 3 (SD 038)

Euphorbia aff. *drummondii* (MET 15,030)
Euphorbia aff. *drummondii* (MET 15,211)
Euphorbia aff. *myrtoides* (MET 12,679)
Euphorbia australis
Euphorbia australis (mid-green form)
Euphorbia boophthona
Euphorbia coghlanii
Euphorbia sp.
Euphorbia sp. (site 1089)
Euphorbia sp. (site 1163)
Euphorbia sp. (site 890)
Euphorbia sp. Harding (MET 15,683)
Euphorbia tannensis ssp. *eremophila*
Euphorbia wheeleri
Evolvulus alsinoides var. *villosicalyx*
Ficus opposita var. *indecora*
Ficus platypoda var. *minor*
Ficus platypoda var. *platypoda*
Fimbristylis aff. *hirsutus* (site 500)
Fimbristylis cephalophora
Fimbristylis depauperata
Fimbristylis dichotoma
Fimbristylis elegans
Fimbristylis littoralis
Fimbristylis microcarya
Fimbristylis rara
Fimbristylis simulans
Fimbristylis sp.
Flaveria australasica
Flaveria sp. Tom Price (MET 11,246)
Flueggea virosa ssp. *melanthesoides*
Gastrolobium grandiflorum
Glinus lotoides
Glycine canescens
Glycine falcata
Glycine tomentella
Gnephosis arachnoidea
Gompholobium polyzygum
Gomphrena canescens
Gomphrena cunninghamii
Goodenia aff. *cusackiana*
Goodenia aff. *muelleriana*
Goodenia aff. *pascua*
Goodenia cusackiana
Goodenia forrestii
Goodenia lamprosperma
Goodenia microptera
Goodenia muelleriana
Goodenia prostrata
Goodenia sp.
Goodenia sp. (site 1205)
Goodenia sp. (site 92)
Goodenia stellata
Goodenia stobbsiana
Goodenia tenuiloba
Goodenia triodiophila
Gossostigma diandra
Gossypium australe
Gossypium robinsonii
Grevillea berryana
Grevillea nematophylla
Grevillea pyramidalis
Grevillea striata
Grevillea wickhamii var. *aprica*
Hakea chordophylla
Hakea suberea
Halgania gustafsenii
Haloragis gossei
Harnieria kempeana ssp. *muelleri*
Helichrysum gilesii
Heliotropium chrysocarpum
Heliotropium conocarpum
Heliotropium crispatum
Heliotropium cunninghamii
Heliotropium heteranthum
Heliotropium inexplicitum
Heliotropium ovalifolium
Heliotropium pachyphyllum
Heliotropium skeleton
Heliotropium sp.
Heliotropium tenuifolium
Heteropogon contortus
Hibiscus aff. *coatesii*
Hibiscus aff. *coatesii* (MET 15,012)
Hibiscus aff. *coatesii* (MET 15,305)
Hibiscus aff. *coatesii* (site 664)
Hibiscus aff. *coatesii* (site 693)
Hibiscus aff. *coatesii* (site 697)
Hibiscus aff. *coatesii* (site 733)
Hibiscus aff. *coatesii* (site 751)
Hibiscus aff. *goldsworthii*
Hibiscus aff. *platychlamys* (MET 15,067)
Hibiscus aff. *platychlamys* (site 1139)
Hibiscus aff. *sturtii*
Hibiscus aff. *sturtii* (site 1209)
Hibiscus aff. *sturtii* (site 903)
Hibiscus brachychlaenus
Hibiscus brachysiphonius
Hibiscus burtonii
Hibiscus coatesii
Hibiscus gardnerii
Hibiscus goldsworthii
Hibiscus haynaldii
Hibiscus leptocladus
Hibiscus panduriformis
Hibiscus platychlamys
Hibiscus sp.
Hibiscus sp. (site 316)
Hibiscus sturtii var. aff. *campylochlamys* (MET 15,957)
Hibiscus sturtii var. aff. *campylochlamys* (site 172)
Hibiscus sturtii var. aff. *grandiflorus*
Hibiscus sturtii var. aff. *truncatus* (site 1,016)
Hibiscus sturtii var. *campylochlamys*
Hibiscus sturtii var. *truncatus*
Hibiscus trionum var. *vesicarius*
Hybanthus aurantiacus
Indigastrum parviflorum
Indigofera colutea
Indigofera fractiflexa (MS)
Indigofera georgei
Indigofera gilesii ssp. *gilesii*
Indigofera linifolia
Indigofera monophylla (grey leaflet form)
Indigofera monophylla (grey/green leaflet form)
Indigofera monophylla (small leaflet form)
Indigofera rugosa
Indigofera sp.
Indigofera trita
Ipomoea coptica
Ipomoea costata
Ipomoea lonchophylla
Ipomoea muelleri
Ipomoea plebeia
Ipomoea polymorpha
Ipomoea sp.
Ischaemum albovillosum
Iseilema aff. *fragile*
Iseilema dolichotrichum
Iseilema eremaeum
Iseilema fragile
Iseilema membranaceum
Iseilema sp.
Iseilema vaginiflorum
Isotropis atropurpurea
Isotropis forrestii
Ixiochlamys cuneifolia
Jacquemontia pannosa
Jasminum didymum ssp. *lineare*
Josephinia sp. Marandoo (M. Trudgen 1,554)
Kennedia sp. Barowana Hill (M.E. Trudgen 15,617)
Keraudrenia nephrosperma
Keraudrenia velutina ssp. *elliptica* (MS)
Lepidium catapycnon
Lepidium echinatum
Lepidium muelleri-ferdinandii
Lepidium oxytrichum
Lepidium pedicellosum
Lepidium phlebopetalum
Lepidium pholidogynum
Lepidium sp.
Leptochloa neesii

Lipocarpha microcephala
Lobelia heterophylla
Lobelia quadrangularis
Lotus australis
Lotus cruentus
Ludwigia perennis
Lysiana casuarinae
Lysiana murrayi
Maireana georgei
Maireana georgei x Enchylaena tomentosa?
Maireana melanocoma
Maireana planifolia
Maireana planifolia x
Maireana planifolia x villosa
Maireana pyramidata
Maireana sp.
Maireana triptera
Maireana villosa
Malvastrum americanum
Marsdenia australis
Marsilea exarata
Marsilea hirsuta
Marsilea sp.
Maytenus aff. *cunninghamii*
Melaleuca argentea
Melaleuca bracteata
Melaleuca eleuterostachya
Melaleuca glomerata
Melaleuca linophylla
Melhania aff. *oblongifolia*
Melhania oblongifolia
Menkea villosula
Mimulus gracilis
Minuria integerrima
Mirbelia viminalis
Mollugo molluginis
Monachather paradoxus
Muehlenbeckia florulenta
Mukia aff. *maderaspatana* (1) (grey,scabrid, rounded)
Mukia aff. *maderaspatana* (2) (grey, scabrid, serrate)
Mukia aff. *maderaspatana* (3) (green,scabrid, rounded)
Mukia aff. *maderaspatana* (4) (green, not scabrid)
Mukia maderaspatana
Mukia sp. *D* (F of A)
Myriocephalus sp. Coondewanna Flats (S. van Leeuwin 975)
Najas tenuifolia
Neptunia dimorphantha
Neptunia monosperma
Newcastelia cephalantha
Nicotiana benthamiana
Nicotiana benthamii
Nicotiana occidentalis ssp. *obliqua*
Nicotiana occidentalis ssp. *occidentalis*
Nicotiana rosulata ssp. *ingulba*
Nicotiana rosulata ssp. *rosulata*
Nicotiana simulans
Nicotiana sp.
Oldenlandia crouchiana
Oldenlandia galioides
Oldenlandia sp. 'gilgai'
Oldenlandia sp. Mt Montagu (MET 15,027)
Oldenlandia sp. West Angelas (M.E. Trudgen 15,919)
Olearia aff. *xerophila*
Olearia fluvialis
Olearia mucronata
Olearia stuartii
Operculina aequisepala
Ophioglossum lusitanicum
Oxalis aff. *corniculata* (site 654)
Pandorea doratoxylon
Panicum decompositum
Panicum effusum
Panicum laevinode
Panicum sp.
Paraceterach reynoldsii
Paraneurachne muelleri
Parietaria debilis
Paspalidium aff. *clementii* (site 976)
Paspalidium aff. *jubiflorum* (MET 15,807)
Paspalidium clementii
Paspalidium constrictum
Paspalidium rarum
Paspalidium retiglume
Paspalidium sp.
Paspalidium tabulatum
Pentalepis trichodesmoides
Pentatropis linearis
Peplidium sp.
Peplidium sp. E (F of A)
Peplidium sp. Munjina (A.A. Mitchell PRP 595)
Perotis rara
Petalostylis labicheoides
Phyllanthus aridus
Phyllanthus ciccoides
Phyllanthus lacunellus
Phyllanthus maderaspatensis var. *angustifolius*
Pilbara trudgenii
Pimelea holroydii
Pimelea microcephala ssp. *microcephala*
Pittosporum phylliraeoides var. *microcarpa*
Plectrachne melvillei
Plectrachne sp. (MET 10,114)
Plectrachne sp. Mt Ella (M.E. Trudgen 12,739)
Pluchea rubelliflora
Pluchea sp.
Pluchea squarrosa
Pluchea tetranthera
Plumbago zeylanica
Polycarpaea corymbosa
Polycarpaea holtzei
Polycarpaea involucrata
Polycarpaea longiflora
Polycarpaea longiflora (pale form)
Polycarpaea longiflora (red form)
Polygala aff. *isingii*
Polymeria aff. *calycina*
Polymeria ambigua
Polymeria sp. *Hamersley* (MET 11,353)
Pomax rupestris
Porana commixta
Portulaca conspicua
Portulaca oleracea
Portulaca pilosa
Potamogeton tricarinatus
Prostanthera campbellii
Prostanthera striatiflora
*Pseudognaphalium luteo-album**
Pterocaulon serrulatum
Pterocaulon sphacelatum
Pterocaulon sphaeranthoides
Ptilotus ?obovatus
Ptilotus aervoides
Ptilotus astrolasius
Ptilotus auriculifolius
Ptilotus axillaris
Ptilotus calostachyus
Ptilotus carinatus
Ptilotus clementii
Ptilotus exaltatus
Ptilotus exaltatus var. *?exaltatus*
Ptilotus fusiformis var. *fusiformis*
Ptilotus gaudichaudii var. *gaudichaudii*
Ptilotus gomphrenoides var. *gomphrenoides*
Ptilotus helipteroides var. *helipteroides*
Ptilotus incanus var. *elongatus*
Ptilotus macrocephalus
Ptilotus murrayi var. *murrayi*
Ptilotus obovatus
Ptilotus polystachyus
Ptilotus roei
Ptilotus rotundifolius
Ptilotus schwartzii var. *schwartzii*
Ptilotus sp.
Rhagodia eremaea
Rhagodia sp. Hamersley
Rhodanthe charsleyae
Rhodanthe floribunda
Rhodanthe margarethae
Rhodanthe pollackii

Rhodanthe propinqua
Rhyncharrhena linearis
Rhynchosia 'minima'
Rhynchosia cf. *minima*
Rhynchosia sp. Barowanna Hill (MET 15,623)
Rhynchosia sp. Bungaroo Creek (MET 12, 402)
Rhynchosia sp. Chichester (MET 15,225)
Rostellularia adscendens ssp. *adscendens*
Rostellularia adscendens ssp. *adscendens* var. *latifolia*
Rostellularia adscendens ssp. *clementii*
Rotala diandra
Rotala mexicana
Rulingia kempeana
Rulingia kempeana
*Rumex vesicarius**
Ruppia sp.
Rutidosis helichrysoides
Salsola kali
Santalum lanceolatum
Santalum spicatum
Sarcostemma viminale ssp. *australe*
Scaevola acacioides
Scaevola amblyanthera var. *centralis*
Scaevola browniana ssp. *browniana*
Scaevola parvifolia ssp. *pilbarae*
Scaevola spinescens
Schizachyrium fragile
Schoenia ayersii
Schoenoplectus dissachanthus
Schoenoplectus laevis
Schoenoplectus litoralis
Schoenus falcatus
Sclerolaena convexula
Sclerolaena cornishiana
Sclerolaena costata
Sclerolaena densiflora
Sclerolaena eriacantha
Sclerolaena sp.
Sclerolaena tetragona
Senecio lautus ssp. *dissectifolius*
Senecio magnificus
Sesbania cannabina
Sesbania formosa
Setaria dielsii
Setaria surgens
Setaria verticillata
Sida ?arenicola (A.A. Mitchell PRP360)
Sida aff. *cardiophylla* (site 1086)
Sida aff. *cardiophylla* (site 1215)
Sida aff. *cardiophylla* (site 241)
Sida aff. *clementii* (site 1137)
Sida aff. *clementii* (site 628)
Sida aff. *clementii* (site 664)
Sida aff. *clementii* (site 826)
Sida aff. *echinocarpa* (MET 15,350)
Sida aff. *echinocarpa* (site 217)
Sida aff. *echinocarpa* (site 656)
Sida aff. *excedentifolia* (MET 15,961)
Sida aff. *fibulifera 'var. L'*
Sida aff. *fibulifera* (felty edges; site 655)
Sida aff. *fibulifera* (grey; MET 15,783)
Sida aff. *fibulifera* (oblong; MET 15,220)
Sida aff. *fibulifera* (prostrate; A.A. Mitchell 3,572)
Sida aff. *fibulifera* (prostrate; F.H. Mollemans)
Sida aff. *fibulifera* (upright; oval leaves)
Sida arenicola
Sida atrovirens
Sida calyxhymenia
Sida cardiophylla
Sida clementii
Sida echinocarpa
Sida excedentifolia
Sida fibulifera
Sida inclusa
Sida laevis
Sida platycalyx
Sida rohlenae var. *rohlenae*
Sida sp.
Sida sp. 'rugose'
Sida sp. (MET 1,007)
Sida sp. (MET 16,086)
Sida sp. (site 625)
Sida sp. (site 865)
Sida sp. A (Kimberley Flora)
Sida sp. *golden calyces* (H.N. Foote 32)
Sida sp. *spiciform panicles* (E. Leyland sn 14/8/90)
Sida sp. Wittenoom (W.R. Barker 1962)
Sida sp. woolly margins (site 605)
Sida spinosa
Sida trichopoda
Sigesbeckia orientalis
Solanum centrale
Solanum cleistogamum
Solanum coactiliferum
Solanum diversiflorum
Solanum ferocissimum
Solanum gabrielae
Solanum horridum
Solanum lasiophyllum
Solanum nigrum
Solanum phlomoides
Solanum sp. (1) (MET 378)
Solanum sturtianum
*Sonchus oleraceus**
Spartothamnella puberula
Spartothamnella teucriiflora
Spermacoce brachystema
Sporobolus australasicus
Stackhousia intermedia
Stackhousia muricata
Stemodia grossa
Stemodia kingii
Stenopetalum anfractum
Stenopetalum decipiens
Stenopetalum nutans
Stenopetalum velutinum
Streptoglossa adscendens
Streptoglossa bubakii
Streptoglossa cylindriceps
Streptoglossa decurrens
Streptoglossa liatroides
Streptoglossa sp.
Streptoglossa tenuiflora
Striga curviflora
Striga squamigera
Stylidium fluminense
Stylobasium spathulatum
Swainsona canescens
Swainsona complanata
Swainsona decurrens
Swainsona elegantoides
Swainsona formosa
Swainsona kingii
Swainsona leeana
Swainsona maccullochiana
Swainsona oroboides
Swainsona stenodonta
Synaptantha tillaeacea ssp. *tillaeacea*
Taplinia saxatilis
Templetonia egena
Tephrosia aff. *clelandii*
Tephrosia aff. *clementii* (1) (M.E. Trudgen 15,527))
Tephrosia aff. *clementii* (2)
Tephrosia aff. *densa* (M.E. Trudgen 16,150)
Tephrosia aff. *supina* (MET 12,357)
Tephrosia clementii
Tephrosia densa
Tephrosia eriocarpa
Tephrosia rosea var. *clementii*
Tephrosia rosea var. *glabrior*
Tephrosia sp.
Tephrosia sp. aff. *supina* (M.E. Trudgen 12,357)
Tephrosia sp. B (Kimberley Flora)
Tephrosia sp. Bungaroo Creek (MET 11,601)
Tephrosia sp. Cathedral Gorge (F.H. Mollemans 2,420)
Tephrosia stipuligera
Tephrosia supina
Tephrosia uniovulata
Terminalia canescens

Tetratheca sp. (N. Casson colln)
Themeda aff. *triandra* (MET 16,046)
Themeda avenacea
Themeda sp.
Themeda sp. Hamersley Station (MET 11,431)
Themeda sp. Mt Barricade (MET 2,471)
Themeda triandra
Tinospora smilacina
Trachymene oleracea
Trachymene sp. Pilbara
Tragus australianus
Trianthema aff. *kimberleyi* (MET 15,060)
Trianthema glossostigma
Trianthema pilosa
Trianthema sp.
Trianthema triquetra
Tribulus aff. *hirsutus* (site 500)
Tribulus astrocarpus
Tribulus hirsutus
Tribulus macrocarpus
Tribulus platypterus
Tribulus suberosus
Trichodesma zeylanicum
Trichosanthes cucumerina
Tricoryne trudgeni
Triodia ?pungens
Triodia aff. *basedowii*
Triodia angusta
Triodia brizoides
Triodia longiceps
Triodia pungens
Triodia wiseana
Tripogon loliiformis var. 2 (MET 12,760)
Tripogon loliiformis var. 3 (*SD* 080.1)
Triraphis mollis
Triumfetta appendiculata
Triumfetta chaetocarpa
Triumfetta clementii
Triumfetta johnstonii
Triumfetta leptacantha
Triumfetta maconochieana
Triumfetta reflexa
Triumfetta sp.
Typha domingensis
Urochloa gilesii ssp. *occidentalis*
Urochloa piligera
Urochloa pubigera
Vallisneria spiralis
Velleia connata
Velleia discophora
Ventilago viminalis
Vigna lanceolata var. *lanceolata*
Vigna lanceolata var. *latifolia*
Vittadinia arida
Vittadinia dissecta var. *hirta*
Vittadinia obovata
Vittadinia pustulata
Vittadinia virgata
Wahlenbergia gracilenta
Wahlenbergia tumidifructa
Waltheria indica
Waltheria virgata
Whiteochloa aff. *airoides*
Yakirra australiensis
Zaleya galericulata
Zygophyllum iodocarpum

APPENDIX E

Fauna recorded or potentially occurring in the West Angelas Project Area

West Angelas Project Area Fauna Species List

KEY TO ABBREVIATIONS:

Habitat Type:	S	Spinifex Steppe
	C	Cracking Clay
	D	Drainage Line
	R	Riverine
	M	Mulga Woodland
	G	Grassland
	A	Acacia Shrubland
	E	Eucalypt Woodland
	Cf	Rocky Gully/ Cliff Face
	Sa	Sandplain
	B	Boulder Hill
	Sg	Grassland Steppe
	X	Snakewood
	+	Opportunistic or other survey
Area Coding:	CW	Coondewanna West
	MR	Mount Robinson
	KM	Karijini / Marandoo
	4B	Four Corners Bore
	ML	Mount Leal
	MH	Mount Herbert
	WR	Western Route
	WAMA	West Angelas Mine Area
	m	migratory species
	*	predominantly aerial species

Appendix E1: Mammal species recorded in the West Angelas Project Area.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
Native Mammals									
TACHYGLOSSIDAE									
Tachyglossus aculeatus	Echidna								M,Cf
DASYURIDAE									
Dasyurus hallucatus	Northern Quoll			+			R, Cf		
Dasykaluta rosamondae	Little Red Kaluta					D,S	D, Sa		D,+
Ningaui timealeyi	Pilbara Ningaui	M	M		M,S	D	C,Sa, D		S,+
Planigale ingrami	Long-tailed Planigale				G	X	C		+
Planigale maculata	Common Planigale						Sa		S,+
Pseudantechinus macdonnellensis	Fat-tailed Pseudantechinus								Cf
Sminthopsis macroura	Stripe-faced Dunnart	G			G,M	X	C, Sa	C	M,C
Sminthopsis ooldea	Ooldea Dunnart		S						M
PERAMELIDAE									
Macrotis lagotis	Bilby			+					+
MACROPODIDAE									
Petrogale rothschildi	Rothschild's Rock-Wallaby						Cf	Cf	Cf
Macropus robustus	Euro	G,M,S		+	M,S	+	C,R,S	C,Sg, R	M,Cf,C, D
Macropus rufus	Red Kangaroo	G	A,E, M	+	G,M		C,D,Sa		M,D,+
MEGADERMATIDAE									
Macroderma gigas	Ghost Bat	+							Cf
EMBALLONURIDAE									
Taphozous hilli	Hill's Sheath-tail Bat	+					Cf		Cf
Taphozous georgianus	Common Sheath-tail Bat								+
MOLOSSIDAE									
Chaerephon jobensis	Northern Mastiff-bat			+					
Mormopterus beccarri	Beccarri's Freetail Bat		M	+	M				
Nyctinomus australis	White-striped Freetail Bat			+					
VESPERTILIONIDAE									
Chalinolobus gouldii	Gould's Wattled Bat		M		M				M,Cf
Vespadelus finlaysoni	Western Cave Eptesicus			+					Cf
Nyctophilus geoffroyi	Lesser Long-eared Bat		M	+					
MURIDAE									
Zyzomys argurus	Common Rock-rat						B,Cf,C, D	C,Sg	Cf
Leggadina lakedownensis	Lakeland Downs Mouse				G		C,D		C
Pseudomys chapmani	Pebble-mound Mouse		S	+	+	S	D	D	M,S
Pseudomys hermannsburgensis	Sandy Inland Mouse	M	A,D, M,S		S	D	C,D,R, Sa		M,D,Sa
Pseudomys delicatulus	Delicate Mouse						D		
Introduced Mammals									
Canis lupus dingo	Dingo	M	S	+	M		Sa	C	C,D,+
Bos taurus	Cattle		D,M	+	M,S		R	Sg	
Equus caballus	Horse		A,D, M	+					
Equus asinus	Donkey			+					
Felis catus	Feral Cat			+					M,D,S
Mus musculus	House Mouse	M	A,D, M,S	+	M,S	D	C,D,R		M,C,D
Oryctolagus cuniculus	Rabbit		S						
TOTAL NUMBER OF SPECIES OBSERVED:		9	13	16	13	8	18	7	24

Appendix E2: Avian species recorded in the West Angelas Project Area.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
Non-passerine									
CASUARIIDAE									
Dromaius novaehollandiae	Emu	S	+	+	+		D	+(D)	M,+
PELECANIDAE									
Pelecanus conspicillatus	Australian Pelican				+				
PHALACROCORACIDAE									
Phalacrocorax sulcirostris	Little Black Cormorant						R		
Phalacrocorax melanoleucos	Little Pied Cormorant						D,R	+	
ARDEIDAE									
Ardea pacifica	Pacific Heron		+				R		
Ardea novaehollandiae	White-faced Heron						R	R	
Nycticorax caledonicus	Nankeen Night Heron						R	R	
THRESKIORNITHIDAE									
Threskiornis spinicollis	Straw-necked Ibis						+(R)		+
ANATIDAE									
Anas superciliosa	Pacific Black Duck						R		
Cygnus atratus	Black Swan						+(R)		
ACCIPITRIDAE									
Elanus axillaris	Black-shouldered Kite*				G		Sa		
Milvus migrans	Black Kite*			+			+(S)		
Haliastur sphenurus	Whistling Kite*	S			+		R	R	M
Accipiter fasciatus	Brown Goshawk*		S	+			+(R)		M
Accipiter cirrhocephalus	Collared Sparrowhawk*			+	+		+(R)		M
Aquila audax	Wedge-tailed Eagle*			+	+		Cf,R	C	M,+
Hieraaetus morphnoides	Little Eagle*		+						
Circus assimilis	Spotted Harrier*	M	+	+	+		C		C,D
FALCONIDAE									
Falco peregrinus	Peregrine Falcon*			+					
Falco longipennis	Australian Hobby*			+					+
Falco hypoleucos	Grey Falcon*	G							+
Falco berigora	Brown Falcon*	G,M,S	A,M	+		X	+	Sg	M,Cf,C, D,S
Falco cenchroides	Australian Kestrel*	G,M		+	S	D	C,Cf, D,R		Cf,C,Sa
TURNICIDAE									
Turnix velox	Little Button-quail	G,M	A,M		S		C,D	R	M,C,Sa
OTIDIDAE									
Ardeotis australis	Australian Bustard	G	+	+			+(S)		C,Sa
BURHINIDAE									
Burhinus grallinius	Bush Thick-knee						+(S)	R	
CHARADRIIDAE									
Elseyornis melanops	Black-fronted Dotterel			+			D,R	R,Sg	
Vanellus tricolour	Banded Lapwing				+				
COLUMBIDAE									
Geopelia striata	Peaceful Dove			+			D,R	R	
Geopelia cuneata	Diamond Dove	M,S		+		D,S,X	D,R	R,Sg	M,C,+
Phaps chalcoptera	Common Bronzewing	M	A,M, S	+	+			C,R	M,C,S,+
Ocyphaps lophotes	Crested Pigeon		A,D,E ,M	+	G,M	X	D,Sa	+	C,+
Geophaps plumifera	Spinifex Pigeon			+	S	S	C,Cf, D,R,S a	C,D, R,Sg	C,Sa
CACATUIDAE									
Cacatua roseicapilla	Galah		E,M	+	+		C,Cf, D,Sa	C,Sg	C,+
Cacatua sanguinea	Little Corella		+	+	S		D,R,S a	R,Sg	Sa
Nymphicus hollandicus	Cockatiel	G			G		D		
PSITTACIDAE									
Melopsittacus undulatus	Budgerigar	G,M		+			C,D, R		M,C,+
Barnardius zonarius	Port Lincoln Ringneck	M,S	D,E, M	+	M,S	S,X	D,Sa	C	Cf,C,D,S
Neophema bourkii	Bourke's Parrot	G,M	A						C
Psephotus varius	Mulga Parrot								+
CUCULIDAE									
Cuculus pallidus	Pallid Cuckoo	G,M,S	A,S	+	M,S	X	C,D,S a	Sg	M,Cf,C, D
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	G,M,S	D,S	+	M	X	D,R,S a	R,Sg	M,D,Sa
Centropus phasianinus	Pheasant Coucal						D	R,Sg	

Appendix E2: continued.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
TYTONIDAE									
Tyto alba	Barn Owl				+				
STRIGIDAE									
Ninox novaeseelandiae	Southern Boobook			+			C	Sg	M
Ninox connivens	Barking Owl			+					
PODARGIDAE									
Podargus strigoides	Tawny Frogmouth			+		X			M,+
AEGOTHELIDAE									
Aegotheles cristatus	Owlet-nightjar		+	+	S				+
CAPRIMULGIDAE									
Eurostopodus argus	Spotted Nightjar		+	+	+	+	+		Sa,+
APODIDAE									
Apus pacificus	Fork-tailed Swift								+
ALCEDINIDAE									
Dacelo leachii	Blue-winged Kookaburra			+			C,D, R,Sa	R,Sg	
Todiramphus pyrrhopygia	Red-backed Kingfisher	M	M		S	+	Cf,D	C	M,C,+
Todiramphus sanctus	Sacred Kingfisher		D	+			R	R	+
MEROPIDAE									
Merops ornatus	Rainbow Bee-eater			+			C,D, R,Sa	R,Sg	
Passerine									
HIRUNDINIDAE									
Cheramoeca leucosternus	White-backed Swallow								D
Hirundo nigricans	Tree Martin			+			B,R	C,R	+
Hirundo ariel	Fairy Martin		+	+			R	R	
MOTACILLIDAE									
Anthus novaeseelandiae	Richard's Pipit			+			C,Cf, Sa		+
CAMPEPHAGIDAE									
Coracina maxima	Ground Cuckoo-shrike	M	A,M	+					+
Coracina novaehollandiae	Black-faced Cuckoo-shrike	M,S	A,D, M	+	G,M, S	D	C,Cf, R,Sa	C,R	M,Cf,C, D,S
Lalage sueurii	White-winged Triller	G,M, S	+	+				R	C,+
PETROICIDAE									
Petroica goodenovii	Red-capped Robin	G,M	D,M	+	M				M,C
Melanodryas cucullata	Hooded Robin	G,M, S	A,D, M,S	+	M	S,X			M,Cf,C, D,S
Microeca fascinans	Jacky Winter								M
PACHYCEPHALIDAE									
Pachycephalus rufiventris	Rufous Whistler	G,M, S	A,D, M,S	+	M,S	+	C,R		M,Cf,C, D,S
Colluricincla harmonica	Grey Shrike-thrush	M	D,M, S	+	S	D		R	M,Cf
Oreoica gutturalis	Crested Bellbird	G,M, S	A,D, M,S	+	M,S	X	Sa	+	M,Cf,C, D,Sa
DICRURIDAE									
Rhipidura albicauda	White-tailed Fantail	Cf,M	D,M	+			R		+
Rhipidura leucophrys	Willie Wagtail	G,M, S	A,E, M,S	+	G,M, S	X	C,Cf, D,R,Sa	C,R,Sg	M,Cf,C, D,S
Grallina cycanoleuca	Australian Magpie-lark		S	+	G,M		C,R,Sa	R,Sg	Sa
CINCLOSOMATIDAE									
Psophodes occidentalis	Chiming Wedgebill					D			
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush								M
POMATOSTOMIDAE									
Pomatostomus temporalis	Grey-crowned Babbler	G,M	A,D, M	+	M				Cf,C
Pomatostomus superciliosus	White-browed Babbler	M	D,M						M
SYLVIIDAE									
Eremiornis carteri	Spinifexbird	M	A,D,S		S	+	C,D,Sa	C,Sg	
Cincloramphus mathewsi	Rufous Songlark	G	D,M	+			+(R)	R	C,+
Cincloramphus cruralis	Brown Songlark	M		+					
Mirafra javanica	Singing Bushlark		M		G		C	C	
Acrocephalus stentoreus	Clamorous Reed-Warbler						R	R	
MALURIDAE									
Malurus cyaneus	Splendid Fairy-wren	M							M,+
Malurus lamberti	Variegated Fairy-wren	M,S	A,D,S	+	M,S	D,S,X	C,D, R,Sa	R,Sg	M,Cf,D

Appendix E2: continued.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
MALURIDAE cont.									
Malurus leucopterus	White-winged Fairy-wren	G	S	+	S	+	C,D,Sa	C	M,C,Sa
Stipiturus ruficeps	Rufous-crowned Emu-wren	S		+					S,+
Amytornis striatus	Striated Grasswren						D	Sg	S,+
PARDALOTIDAE									
Sericornis brunneus	Redthroat	M		+					M
Acanthiza apicalis	Inland Thornbill	M	M	+					M,S
Acanthiza robustirostris	Slaty-backed Thornbill		D,M	+	M				M
Acanthiza uropygialis	Chestnut-rumped Thornbill	G,M,S	A,D, M	+	M,S				M
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			+					+
Smicrornis brevirostris	Weebill	S	A,D, M,S	+	M,S	S	D,Sa	C,Sg	M,Cf,D, S
Gerygone fusca	Western Gerygone	M,S	A,D, M,S	+	M,S				M
Pardalotus rubricatus	Red-browed Pardalote			+	S	S	D,R	R,Sg	D
Pardalotus striatus	Striated Pardalote	S	M,S	+	S		+(R)		M,Cf,S
NEOSITTIDAE									
Daphoenositta chrysoptera	Varied Sittella	M	A	+					M,Cf
CLIMACTERIDAE									
Climacteris melanura	Black-tailed Treecreeper	S		+	+				+
MELIPHAGIDAE									
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	G,M,S	A,D, M,S	+	M,S	D			M,Cf,C, D,S
Manorina flavigula	Yellow-throated Miner	M	D,E, M	+	M,S	S	B,Cf, R,Sa	C,R,Sg	Cf,D
Lichenostomus virescens	Singing Honeyeater	M,S	A,D, M,S	+	G,M, S	S,X	B	C	M,Cf,C, S,Sa
Lichenostomus keartlandi	Grey-headed Honeyeater	S	S	+	S	D,S	C,Cf, D,Sa	C,R,Sg	M,Cf,S
Lichenostomus penicillatus	White-plumed Honeyeater		D,E	+			C,R	R,Sg	D,+
Lichmera indistincta	Brown Honeyeater	S		+	S	D	C,D, R,Sa	R,Sg	Cf,D
Melithreptus laetior	Golden-backed Honeyeater			+			R		+
Phylidonyris albifrons	White-fronted HE	M,S	S	+					M,Cf,C
Conopophila whitei	Grey Honeyeater	+(M)	+(M)	+					+
Certhionyx niger	Black Honeyeater			+					+
Certhionyx variegatus	Pied Honeyeater			+					Cf,+
Epthianura tricolor	Crimson Chat	S		+					+
ZOSTEROPIDAE									
Zosterops lateralis	Silvereye						D,R	R	
DICAEIDAE									
Dicaeum hirundinaceum	Mistletoebird	M,S	D	+	M				
PASSERIDAE									
Emblema pictum	Painted Firetail			+	S	D,S	C,D, R,Sa	C,D, R,Sg	M,Cf
Poephila guttata	Zebra Finch	G,M,S	A,D,E ,M,S	+	G,S	D,S	C,D, R,Sa	C,R,Sg	M,C,D,Sa
Neochmia ruficauda	Star Finch						+(R)	R	
PTILONORHYNCHIDAE									
Chlamydera guttata	Western Bowerbird	M	S	+		X	+(D)	R,Sg	Cf
ARTAMIDAE									
Artamus cinereus	Black-faced Woodswallow	G,M,S	A,D, M,S	+	G,M, S	D,S	Cf,D, Sa	C,D, R,Sg	M,Cf,C
Artamus minor	Little Woodswallow			+			Cf		Cf,S
CRACTICIDAE									
Cracticus torquatus	Grey Butcherbird	G,M	A,D, M	+	M,S				M,C,D
Cracticus nigrogularis	Pied Butcherbird	M	D	+	M,S	X	C,Cf, R,Sa	C,D, R,Sg	M,Cf,C, S
Gymnorhina tibicen	Australian Magpie		D,E, M,S	+	G,S		Cf,D	R	C,+
CORVIDAE									
Corvus bennetti	Little Crow			+					
Corvus orru	Torresian Crow	G,M,S	A,M	+	M,S	D	Sa	R,Sg	M,+
TOTAL NUMBER OF SPECIES OBSERVED:		**58**	**60**	**85**	**56**	**34**	**76**	**57**	**86**

Appendix E3: Herpetofauna recorded in the West Angelas Project Area.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
Amphibians									
MYOBATRACHIDAE									
Limnodynastes spenceri	Spencer's Frog						Sa		
Pseudophryne douglasi								D	
Uperoleia russelli	Russell's Toadlet						R		
HYLIDAE									
Cyclorana maini	Main's Frog								+
Litoria rubella	Desert Tree Frog			+			D,R	D,R	Sa
Tortoises									
CHELIDAE									
Chelodina steindachneri	Flat-shelled Tortoise			+					
Lizards									
GEKKONIDAE									
Crenadactylus ocellatus	Clawless Gecko								Sa
Diplodactylus elderi	Jewelled Gecko								+
Diplodactylus pulcher									+
Diplodactylus stenodactylus				+			Sa		+
Diplodactylus wellingtonae			D						+
Gehyra pilbara	Pilbara Dtella				+(S)		Cf	D,Sg	+
Gehyra punctata	Spotted Dtella	+					Cf,D, R,Sa	Sg	Cf,Sa,+
Gehyra variegata	Tree Dtella	M,S	D,M	+	M,S		Sa		M,Cf,C, D
Heteronotia binoei	Bynoe's Gecko	M,S		+	M,S				Cf,D,S,+
Nephrurus wheeleri cinctus					M,S				+
Oedura marmorata	Marbled Velvet Gecko								Cf
Underwoodisaurus milii	Barking Gecko								Cf
PYGOPODIDAE									
Delma borea							D		+
Delma butleri							Sa		
Delma elegans									M
Delma nasuta				+			D		+
Delma pax			M				R		
Lialis burtonis	Burton's Snake Lizard		M,S						+
AGAMIDAE									
Caimanops amphiboluroides			M		M				+
Ctenophorus caudicinctus	Ring-tailed Dragon		D		M,S		Cf,D, R	D,R,Sg	M,C,S
Ctenophorus isolepis	Military Dragon		A				D,Sa	R	+
Ctenophorus reticulatus	Western Netted Dragon		M						+
Diporiphora valens					S				+
Diporiphora winneckei			A		M				
Lophognathus longirostris			E			D	D,R,Sa	D,R,Sg	D,+
Pogona minor	Dwarf Bearded Dragon	G	D,M, S		M,S		R		M,C
Tympanocryptis cephalus							C	Sg	+
SCINCIDAE									
Carlia munda			D	+	S	D			+
Cryptoblepharus plagiocephalus	Fence Skink			+	M		B		M,Sa
Ctenotus duricola			A				Sa		+
Ctenotus grandis titan					S				+
Ctenotus helenae				+		S	C,D		D
Ctenotus aff. *helenae*			A,D	+					
Ctenotus leonhardii							D		
Ctenotus pantherinus		M	A,D	+	M,S,X		D,Sa		+
Ctenotus piankai							Sa		Sa
Ctenotus rubicundus							Cf		+
Ctenotus rutilans									M,S
Ctenotus saxatilis			M	+					M,S
Ctenotus schomburgkii									M
Cyclodomorphus melanops	Gunther's Skink	M,S	D	+	M				M,D,S
Egernia depressa							Cf		+
Egernia formosa		+(S)							
Eremiascincus richardsonii	Broad-banded Sand Swimmer		D						

Appendix E3: continued.

Species Name	Common Name	CW	MR	KM	4B	ML	MH	WR	WAMA
SCINCIDAE cont.									
Lerista flammicauda		S					Cf		+
Lerista muelleri		M,S	S	+	M,G			Sg	M,S
Menetia surda			M		M				+
Morethia ruficauda exquisita	Three Striped Fire-tail			+			Cf	Sg	Cf,S
Notoscincus butleri							D,Sa		
Sphenomorphus isolepis							R		
Tiliqua multifasciata	Central Blue-tongue Lizard		S	+	M,S				+
VARANIDAE									
Varanus acanthurus	Ridge-tailed Monitor							Sg	Cf,+
Varanus caudolineatus	Stripe-tailed Monitor				M,S				+
Varanus eremius							Sa		
Varanus giganteus	Perentie				M				+
Varanus gilleni	Pygmy Mulga Monitor		D,M		M				
Varanus panoptes			+(M, S)		M		R		
Varanus tristis			M		M				D,+
Varanus sp. nov.							R		M
Snakes									
TYPHLOPIDAE									
Ramphotyphlops grypus				+	S				
Ramphotyphlops hamatus			M	+					+
Ramphotyphlops waitii				+					
BOIDAE									
Aspidites melanocephalus								R	
Liasis perthensis	Pygmy Python	S							Cf,Sa
Liasis stimsoni	Stimson's Python					+	S		Cf
ELAPIDAE									
Acanthophis pyrrhus	Desert Death-Adder		S						Cf,+
Demansia psammophis	Yellow-faced Whipsnake			+					+
Demansia rufescens	Rufous Whipsnake			+					
Pseudechis australis	Mulga Snake		+(M, S)						Cf,S,+
Pseudonaja modesta	Ringed Brown Snake	M		+					
Pseudonaja nuchalis	Gwardar		+(M)						M,+
Suta fasciata	Rosen's Snake		+(M)						
Suta monachus	Hooded Snake		+(S)	+					
TOTAL NUMBER OF SPECIES OBSERVED		**10**	**30**	**22**	**23**	**4**	**32**	**12**	**56**