PART C

Strategic Proposal Impact Assessment

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7 IMPACT ASSESSMENT APPROACH

This PERSP identifies and assesses the significance of potential impacts to each key environmental factor as a result of the future implementation of the Strategic Proposal. The impact assessment has been informed by a number of key inputs as shown in Figure 10 and described below.

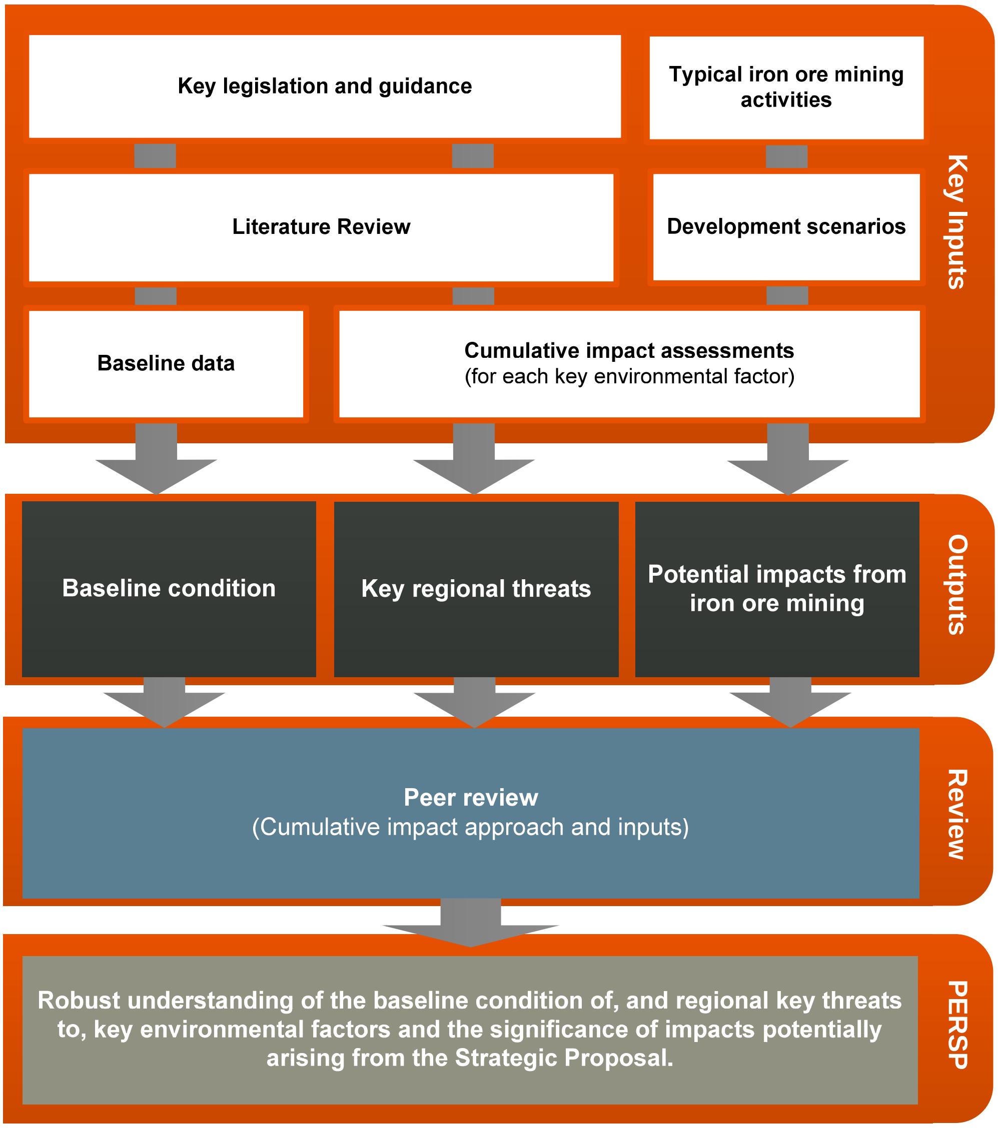


Figure 10: Key inputs into this PERSP

The typical iron ore mining–related activities proposed as the scope of the Strategic Proposal (Section 7.2) are examined for impact to the environmental factors under each of the following development scenarios (Section 7.4):

- Existing Development;
- 30% Conceptual Development; and

- Full Conceptual Development.

These development scenarios are discussed in detail in Section 7.4.

The impact assessment considers impacts at a regional scale and, in doing so, defines the key regional threats and the key environmental assets and values of the Pilbara region. This approach helps to better inform management priorities at the strategic and regional level. Additionally, this PERSP also considers the impacts that are directly attributable to BHP Billiton Iron Ore activities and thus helps to inform the adaptive management approach detailed in Section 12.1.1.

7.1 Key Legislation and Guidance

The EPA is required to have regard to the principles set out in section 4A of the EP Act in its assessment of the Strategic Proposal and report to the Minister for Environment. It must also take into account all relevant administrative procedures, assessment criteria and policies which it has promulgated and which are operative at the time it undertakes its assessment of the environmental impact of the Strategic Proposal. Other legislation, non-EPA policies and other regulatory guidance may also be relevant to the EPA's assessment.

The key legislation, policies and other regulatory guidance (together referred to as guidance materials) relevant to the key environmental factors for the Strategic Proposal were identified in Section 6.4, Table 7.2.3 and Appendix A of the ESD (BHP Billiton Iron Ore 2013).

Since the ESD was published in November 2013, there have also been changes to some of the guidance materials identified in the ESD as relevant to the Strategic Proposal. For example, some guidance materials have been withdrawn by the EPA, or superseded. All relevant guidance material has been considered in preparing the PERSP and has been listed by Factor in Appendix 1.

BHP Billiton Iron Ore has also implemented processes to ensure that new guidance materials developed since the ESD have been identified and considered in relation to the PERSP. This includes both relevant guidance materials that the EPA must take into account in its assessment of the Strategic Proposal, and further non-EPA guidance materials that have provided some assistance to BHP Billiton Iron Ore in understanding and assessing the potential impacts of the Strategic Proposal.

BHP Billiton Iron Ore also recognises that key legislation and guidance will change over the life of the Strategic Proposal. While this PERSP is based on current guidance materials, the Derived Proposal process (as described in Section 4.2.3) allows for new and updated legislation and other guidance materials to be considered during the validation of this impact assessment.

Relevant guidance materials are listed for each of the key environmental factors in Appendix 1. The tables included for each key environmental factor outline how the guidance materials are relevant, and have been applied in the context of the Strategic Proposal.

7.2 Typical Activities for Iron Ore Mining

The scope of the Strategic Proposal is described in Chapter 2. As detailed design has not yet been undertaken for mining operations and associated activities within the scope, the PERSP uses the activities described for typical iron ore mining as a conceptual basis to the impact assessment. This section describes the types of activities and infrastructure characteristic of BHP Billiton Iron Ore's Pilbara iron ore mines.

These typical activities have been utilised in order for environmental impact assessment to be undertaken at this strategic level. While the types of activities required for iron ore mining can vary, the impacts to the environment from these activities are generally considered to be:

- ground disturbance (vegetation, habitat and landform removal);
- emissions to the environment; and

- abstractions from the environment.

The following section describes typical mining activities, including associated infrastructure, considered in the impact assessment. Activities include:

- preconstruction;
- construction;
- mining;
- non-process infrastructure;
- waste management;
- water management; and
- closure and decommissioning.

7.2.1 PRECONSTRUCTION: CLEARING AND GROUND DISTURBANCE

Vegetation clearing and preliminary earthworks (ground disturbance) are usually early steps in the development of a new mine or supporting infrastructure.

Clearing of vegetation is usually required (although not always in the case of a brownfield expansion). Cleared vegetation and soils are stockpiled for later use in rehabilitation activities around the site to aid in the return of vegetation and the creation of fauna habitat.

Ground disturbance is currently managed in accordance with a standard BHP Billiton Iron Ore land disturbance procedure, described further in Section 8.1.3.3. This process will continue into the future, either in its current form or in accordance with an equivalent standard land disturbance procedure. The current procedure is designed to manage environmental, heritage, land tenure and legal commitments prior to and during land clearing. The procedure is the mechanism whereby project-specific technical and professional advice, such as topsoil management measures, can be captured and implemented.

7.2.2 CONSTRUCTION ACTIVITIES

The anticipated construction phase for a typical mining operation is approximately 30 months. The construction phase would involve bulk earthworks, installation of infrastructure and prestripping activities in preparation for mining.

Key activities include construction of laydown areas, borrow pits, roads, concrete batch plant, non-processing infrastructure, power and water distribution facilities, primary crushing facilities, ore handling plant, stockyard, train load-out facilities, overland conveyors and the rail loop. Towards the end of the mine construction phase, major infrastructure components (e.g. the ore handling plant) are tested and commissioned.

The construction phase includes prestripping the first pit. Ore encountered during prestrip would be preferentially stockpiled on the primary crusher run-of-mine pads or on approved disturbance areas until the ore handling plant is commissioned. Overburden is used for construction purposes (preferentially to opening borrow pits) or stockpiled within overburden storage areas (OSAs).

7.2.3 MINING OPERATIONS

7.2.3.1 MINING

The following subsections describe the typical main activities and equipment involved in mining (i.e. excavating the ore).

Mine Planning

Individual mine plans will be developed based on detailed resource definition, market conditions and the interaction of the mine as part of BHP Billiton Iron Ore's integrated Pilbara mining operations.

Mining Method

Mining would follow conventional open-cut iron ore mining methods used in the Pilbara (Figure 11 and Plate 7). Future technological advances (e.g. continuous mining) may result in changes to contemporary mining methods.

The general method involves the mining of ore and overburden using conventional drill, blast, load and haul. Following blasting, the unprocessed, broken ore (the run-of-mine) and overburden would be loaded by hydraulic excavators or front-end loaders into the haul trucks. Ore would be transported to run-of-mine pads for primary crushing or would be placed in low-grade ore stockpiles. Overburden would be either retained within the pit for use as in-fill or removed from the pit area to out-of-pit OSAs.

Open pits will be selectively mined in accordance with the site mine plan. Mining will generally occur both above and below the water table. Mining operations could be conducted for up to 24 hours per day, seven days per week.

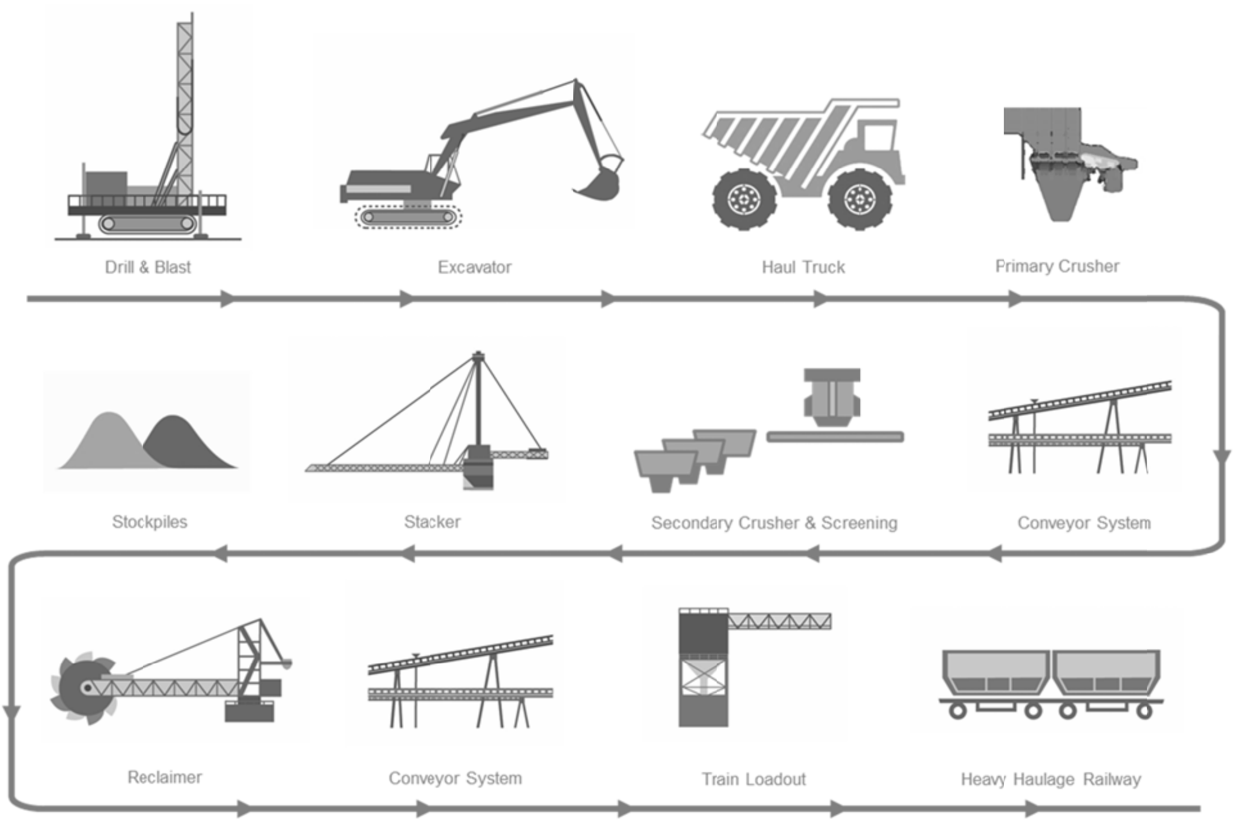
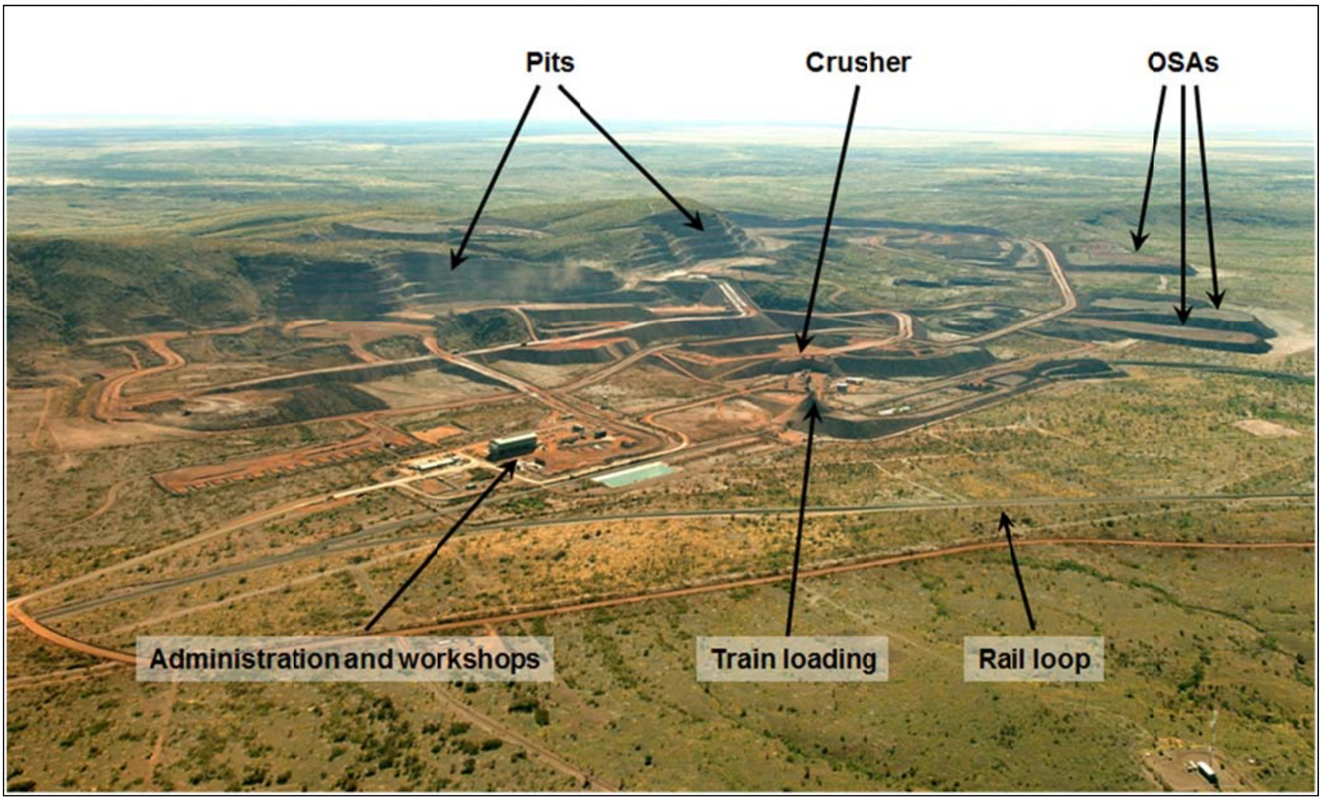


Figure 11: Components of a typical mining operation



Source: BHP Billiton Iron Ore.

Plate 7: Typical mine layout overview

Blasting

Pit benches will be drilled and blasted to the required depth. The number of holes and the quantity and type of explosives will be adjusted to suit the rock conditions and design objectives of the blasts. Based on current practices, the main explosives will be ammonium nitrate fuel oil and bulk blasting emulsion products. Future technological advances may result in changes to contemporary blasting methods.

Mine Fleet

The mobile mining fleet would comprise haul trucks (Plate 8), excavators, front-end loaders, drill rigs and ancillary vehicles, including bulldozers, water carts and graders. The actual type and number of mobile mining fleet vehicles will vary during the mine life, depending on such factors as the number and location of open mining areas, mining rate, and ore and overburden characteristics.

Source: BHP Billiton Iron Ore.
Plate 8: Haul truck

Mine Dewatering

To access ore below the water table, production bores and in-pit sumps would be used to dewater the open pits. The dewatering pumping rates would be likely to fluctuate in response to aquifer characteristics, the mine plan, operational water demands and weather conditions. In-pit pumping, conducted seasonally to remove incidental stormwater, would be used in addition to the dewatering pumping.

Abstracted water would be required for such activities as dust suppression, mine water supply and environmental purposes. Options for disposal of excess water include managed aquifer recharge, surface discharge and water sharing with other nearby mines or agreed end-users. These options are discussed further within Section 8.2.2. Dewatering of pits ahead of mining may also be required, depending on their depth to groundwater.

Overburden Storage

Storage of overburden is required from the prestrip period of construction throughout operations. OSAs are shaped as mining progresses and remain in place at closure as part of the final landform. Overburden from operational pits would be used to in-fill mined-out portions of the pits where mine scheduling allows. Overburden stored in this fashion is referred to as in-pit OSAs. Where this is not possible, the overburden would be placed in out-of-pit OSAs. OSAs will be constructed to a site-specific defined maximum height.

Final batter slopes would unlikely to be greater than approximately 20 degrees. Final OSA designs would be informed by ongoing materials characterisation and rehabilitation programs.

7.2.3.2 ORE PROCESSING, STOCKPILING AND TRANSPORT

Mined ore would be hauled from the open pits to the nearest primary crushing facilities. Overland conveyors are one option to transport the ore from the primary crushers to a coarse ore stockpile, located adjacent to the centralised ore handling plant. After crushing and screening, ore would be conveyed to a stockyard located near the train load-out facilities from where it would be loaded onto trains for transport to BHP Billiton Iron Ore's Port Hedland port facilities.

Primary Crushers and Overland Conveyors

The primary crushers are generally located adjacent to the open pits. Haul trucks then feed ore into the run-of-mine bin located over the primary crusher. The crushed ore would then be fed onto the overland conveyor system linking the primary crushers to the coarse ore stockpile.

Ore Handling Plant

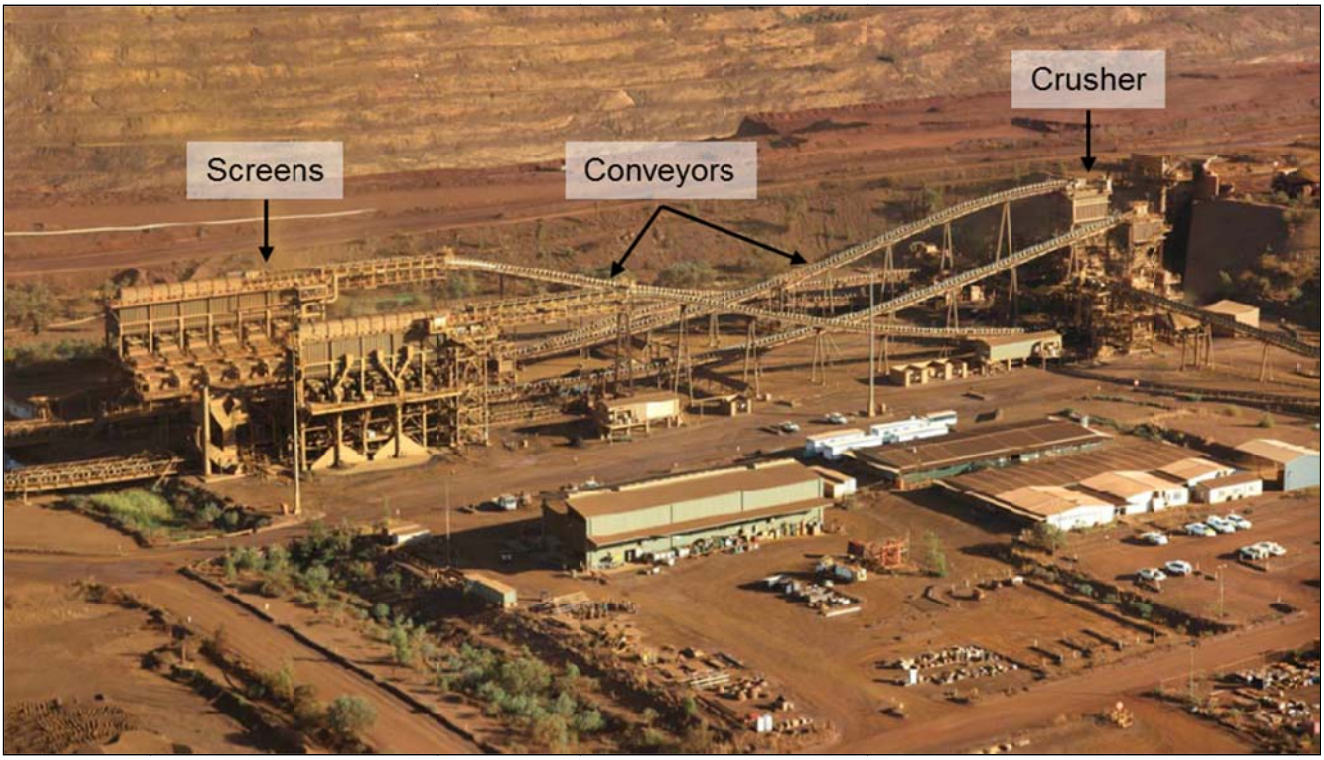
The coarse ore stockpile generally receives ore from one or more primary crushers and would be located adjacent to the ore handling plant. The ore handling plant would comprise scalping screening, product screening and secondary crushing units. Ore would be crushed and screened to fines (ore crushed to around 6 mm in size) or lump (around 6 to 30 mm in size) 'products'.

Some ore may be classified as 'low grade' due to impurities and may be transported to low-grade ore stockpiles for beneficiation. The beneficiation process may involve washing the low-grade ore to remove impurities to achieve customer specifications. Tailings material generated by this process would be stored in a tailings storage facility.

Plate 9 shows an aerial image of a typical iron ore handling plant. The key components of the ore handling plant – crushers (to the right of the image), conveyors (centre) and screens (left) – are visible in the plate.

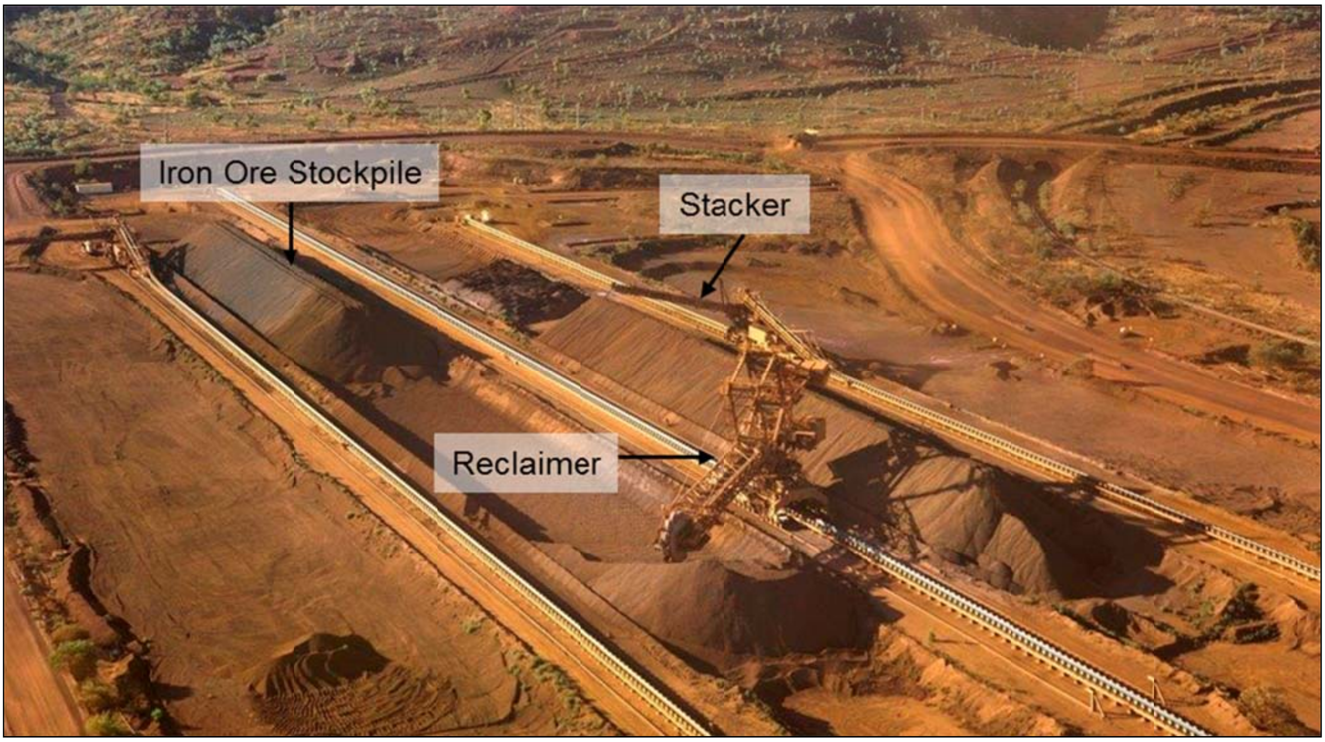
Ore Stacking, Reclaiming and Loading

Generally, two ore stacking circuits (lump and fines) would receive ore from the ore handling plant and discharge it onto separate stockpiles via luffing or slewing stackers. Ore could be reclaimed from the stockyard using a bucketwheel reclaimer (Plate 10) and then be discharged via the train load-out feed conveyor to the train load-out bin. The train load-out may consist of a mass flow bin located on a single rail loop. Both lump and fines material could be loaded through the bin, which would generally be designed to fully empty between products.



Source: BHP Billiton Iron Ore.

Plate 9: Typical iron ore handling plant



Source: BHP Billiton Iron Ore.

Plate 10: Typical stockpile configuration

Ore Transport (Rail)

Operations are anticipated to utilise the existing rail network (Plate 11), as well as new spur lines and potential additional parallel expansions to the existing alignments to transport processed ore to port facilities for export.

Ore would be loaded onto trains at the train load-out facilities at each typical mining operation and transported off-site.

Source: BHP Billiton Iron Ore.

Plate 11: BHP Billiton Iron Ore rail infrastructure

7.2.4 NON-PROCESS INFRASTRUCTURE, SERVICES AND FACILITIES

7.2.4.1 ADMINISTRATION, WORKSHOP AND AUXILIARY FACILITIES

Administration Buildings

The administration buildings would provide air-conditioned offices and facilities for administration and operational staff. The buildings are likely to be a conventional modular transportable design.

Workshops and Other Areas

Workshop and warehouse buildings and associated hardstand areas may be installed to provide fixed plant and mobile equipment maintenance facilities, hydrocarbon storage, heavy and light vehicle wash down areas, and laydown areas for equipment and consumables storage. A sample preparation and laboratory building may also be installed.

A mine access security gatehouse, concrete batch plant, communication facilities and turkey's-nest dams would typically be required within the mine site.

Accommodation

Dedicated worker accommodation may be constructed to service one or more mining operations. The accommodation is typically single-person rooms with common administration, medical, dining, recreation and laundry facilities. Accommodation could be for 300 to over 1,500 people.

Roads

Future mine access roads would connect new or expanded mines to the existing road network. Intra-mine roads would include a network of heavy-vehicle haul roads and light-vehicle access roads and tracks.

Power

Power is likely to be supplied to most typical mining operations (although not necessarily all) by the existing BHP Billiton Iron Ore Pilbara power grid, which is connected to the Newman gas-fired power station. Power requirements for process and non-process infrastructure may be distributed from a centralised substation and switchyard. Power from the substation could be transferred by either overhead or underground cable where necessary. Power during construction may be supplied by temporary on-site diesel generators. Future technological advances may result in alternate power supply sources if they become available and are feasible.

Environmentally Hazardous Goods and Materials

Potential environmentally hazardous and dangerous goods that may be transported, handled and disposed of include but are not limited to diesel, oils and lubricants, coolant, detergents, paints and explosives. Mining may also expose potentially acid-forming material that will require appropriate assessment, handling and management.

Fuel and Hydrocarbon Storage

The typical mining operation assumes a diesel-based transport system for the purpose of the impact assessment. The bulk fuel requirements may be transported to site via train and decanted at a dedicated fuel unloading facility located adjacent to the rail spur.

The main on-site diesel fuel storage tanks would generally be located in the non-processing infrastructure area. Oil, lubricant and coolant storage tanks and facilities may also be installed in this area. All hydrocarbon storage areas would be designed and constructed in accordance with relevant Australian standards.

Future improvements to current diesel-based technologies may result in alternate energy sources or consumption efficiencies.

Explosive Storage

Current blasting technology involves the use of ammonium nitrate fuel oil. Separate explosive storage areas would be located within the mining operation. Explosive storage areas (whether for ammonium nitrate fuel oil or a future technology) would be designed and constructed in accordance with relevant Australian standards.

7.2.5 WASTE MANAGEMENT

Waste materials at a future operation would generally include sewage and effluent, scrap metal, non-metal scrap (e.g. piping, plastic, fibreglass or wood), general refuse, putrescible wastes, tyres, conveyor belts and packaging wastes.

Generally, on-site landfill facilities would be used for the disposal of putrescible and inert waste. Controlled wastes would be collected and transported off site for disposal at a licensed facility in accordance with the Environmental Protection (Controlled Waste) Regulations 2004 or compliance requirements appropriate at the time.

Based on current technology, a typical mining operation may utilise a centralised wastewater treatment plant with lined evaporation ponds for the processing of domestic sewage and wastewater. An irrigation field or other disposal option may also be used. Smaller package wastewater treatment plants and evaporation ponds may also be installed. Solids removed from the wastewater treatment plants would be carted to treated sewage drying beds.

All waste would be managed in accordance with the Environmental Protection Regulations 1987 or future relevant legislation.

7.2.6 WATER MANAGEMENT

7.2.6.1 WATER DEMAND AND SUPPLY

Water may be required for a combination of potable uses, construction, ore conditioning, dust suppression and other operational purposes. Annual potable water demand may be obtained from bores established within or near the project area. A water treatment plant may be installed, if necessary, to treat the water to potable standard.

Water abstracted through dewatering of the deposits would be preferentially used to meet mine water demands. Should there be discrete periods where mine dewatering rates are insufficient to meet the raw water demand, alternative water supplies may be accessed. Potential alternative water sources may include excess water from other mines in the region or water from borefields established in nearby iron ore deposits or local aquifer systems.

The construction of bores and the abstraction of water and its use will be managed under the Country Areas Water Supply (Clearing Licence) Regulations 1981, Country Areas Water Supply By-laws 1957 and Rights in Water and Irrigation Regulations 2000 or future relevant legislation.

7.2.6.2 SURPLUS WATER MANAGEMENT

Various options for managing the surplus water generated during mine dewatering may be considered. The method of surplus water management would depend on the outcome of further technical investigations and feasibility studies. BHP Billiton Iron Ore also supports, in principle, water-sharing agreements, provided this option is economically, socially and environmentally acceptable and in line with approval conditions.

7.2.6.3 DRAINAGE AND STORMWATER MANAGEMENT

The objective of the water management system during operations is to manage all potentially contaminated water generated within the project area, while diverting all other surface water around infrastructure, landforms and open pits areas, where practicable.

Drainage across the project area may be managed using diversion channels, protective bunds around open pits, OSAs or specifically engineered infrastructure. Based on current practice, drainage may be designed to convey surface waters generated by events of up to a 1:100-year average recurrence interval rainfall event.

All major plant and facilities would generally be constructed at an elevation above or protected against a 1:20-year average recurrence interval flood level as a minimum. On-site drainage designs would be used to ensure stormwater within infrastructure areas is appropriately managed. Infrastructure such as roads and the rail loop would be constructed with culverts or another suitable method to manage water flows.

Potentially contaminated water (e.g. wash-down water) would be contained and treated before being reused or discharged.

Water pumped from open pit sumps may be directed to nearby sedimentation basins prior to being used for operational purposes or released. Seasonal stormwater may need to be discharged directly to the surrounding environment should the pit pumping rate exceed the design capacity of the sedimentation basins.

7.2.7 CLOSURE AND DECOMMISSIONING

Mine closure and decommissioning requires consideration and planning of the following:

- earthworks;
- surface treatments including rehabilitation; and
- site contamination.

Rehabilitation earthworks aim to reprofile the land surface to create landforms that are consistent with the surrounding landscape, within the constraints imposed by the physical nature of the materials. This may further require surface water management, which could include the construction of compacted bunds along the crest of the overburden storage areas to prevent surface water runoff.

To facilitate stability and revegetation potential, a number of surface treatments may be used, depending on the size and nature of the area. Typical treatments may consist of one or more of the following:

- deep ripping of compacted surfaces;

- selective application of topsoil material (or alternative growth media) to provide a medium to support plant growth;
- surveyed contour ripping or scarifying of surfaces following the application of soil to maximise water infiltration and enhance revegetation success; and
- selective placement of logs or smaller woody debris or boulders (if available) across the reprofiled surface or constructing rocky cliff features (where potential exists) to provide additional habitat areas for fauna species recorded prior to mining.

Typically, revegetation will use local provenance native seed (from the local area, but as a minimum from within 100 km of site within the Pilbara bioregion) consistent with vegetation associations and native species recorded in the mine area prior to mining. To promote vegetation density, species diversity and plant age heterogeneity, additional seeding (in subsequent years) will be conducted if required.

In areas where the potential for soil contamination is identified assessment will be managed in accordance with Department of Environment and Conservation (or equivalent) requirements including sampling and analysis and remediation or management.

7.3 Literature Review

This PERSP draws on a wide range of material to inform the key components of the impact assessment, which included:

- baseline data consolidation;
- key threats applicable to the key preliminary factors in the Pilbara now and in the future;
- cumulative impact assessment approach; and
- interpretation and discussion of results.

As exact impacts will not be known until the Derived Proposal stage, literature reviews were undertaken as an informed approach to consolidate large amounts of information for use in the impact assessment at a regional scale. The material used that informed the impact assessment are summarised in Chapter 8 and are referenced or provided as appendices where appropriate.

7.4 Development Scenarios

The PERSP presents cumulative impact assessment for each of the key preliminary environmental factors.

To support the quantitative component of the impact assessment, three development scenarios were considered, which include non-mining land uses, third party iron ore mining, and BHP Billiton Iron Ore mining either existing or proposed as part of this Strategic Proposal:

- Existing Development Scenario (defined in Section 7.4.1);
- 30% Conceptual Development Scenario (defined in Section 7.4.2); and
- Full Conceptual Development Scenario (defined in Section 7.4.3).

Indicative footprint areas for the development scenarios are shown in Table 8. Note that the areas are based on conceptual footprint areas within the Project Definition Boundary, which covers a total area of 7,650,074 ha. Disturbance is considered in terms of BHP Billiton Iron Ore's potential footprint, the reasonably foreseeable footprints of other proponents, and other disturbance that may be required for public infrastructure or other purposes.

Table 8: Conceptual footprint areas for each development scenario

	Disturbance Footprints (Ha)*		
Land User	**Existing Development Scenario**	**30% Conceptual Development Scenario**	**Full Conceptual Development Scenario^**
BHP Billiton Iron Ore Mines	18,194	48,394	124,666
Third Party Iron Ore Mines	21,258	68,546	68,546
Other (Non-Mining)	34,534	34,534	34,534
Cumulative	***73,985***	***151,474***	***227,746***

Note: *Disturbance attributable to direct clearing of vegetation only.
^ The Full Conceptual Development Scenario includes the Existing Development Scenario disturbance footprint.

For purposes of the impact assessment, all of BHP Billiton Iron Ore's mine anticipated mine footprints are included, even if they are not within scope of the Strategic Proposal. This provides a conservative assessment of potential impacts.

Figure 12 shows the key inputs used for each of the development scenarios and illustrates the relative proportions of the disturbance footprints for each input under the three development scenarios (as shown in Table 8).

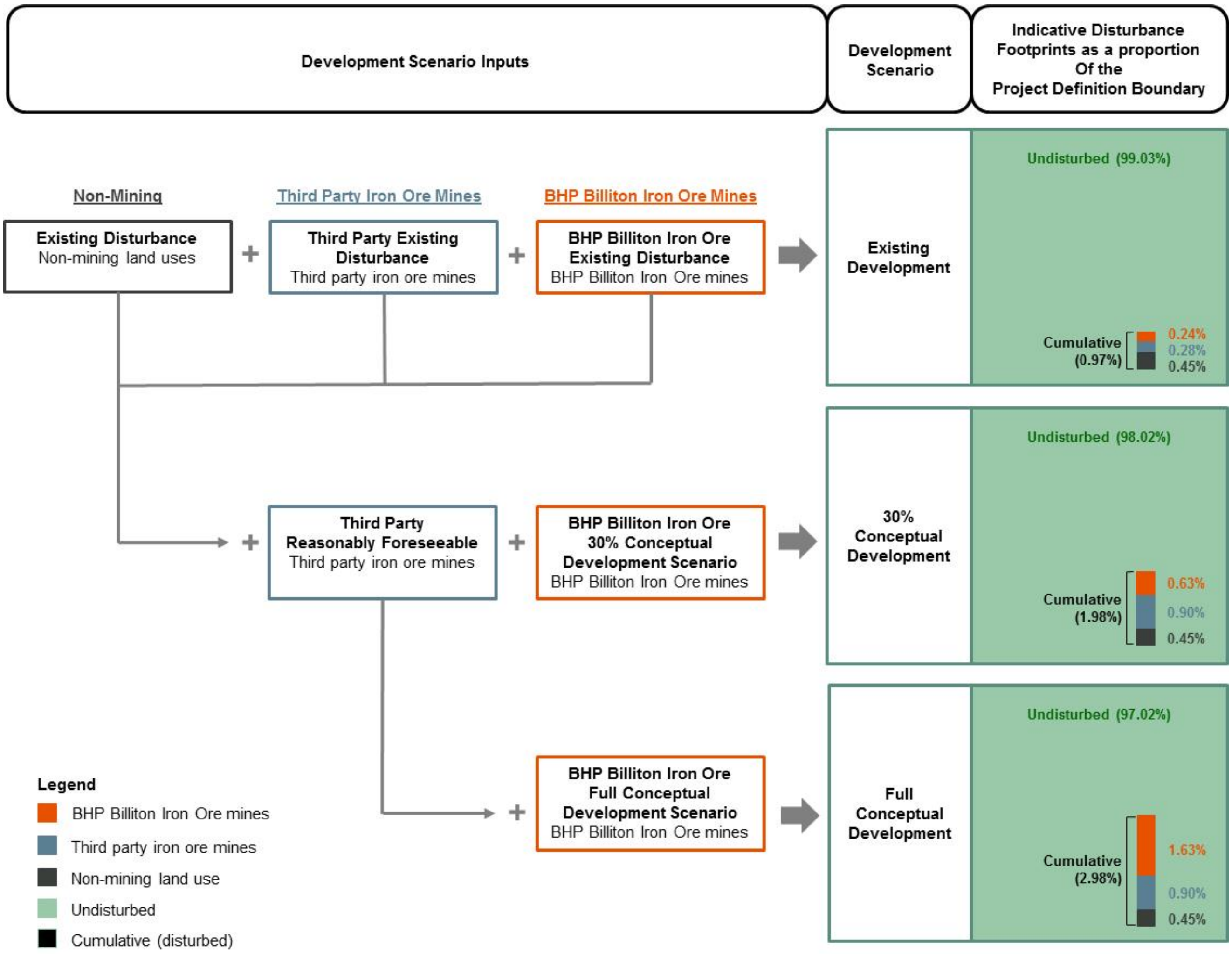


Figure 12: Inputs into each of the development scenarios

The development scenarios and associated footprints are described in further detail in the following sections.

7.4.1 EXISTING DEVELOPMENT SCENARIO

This development scenario represents the existing extent of cumulative direct disturbance within the Project Definition Boundary. The Existing Development Scenario consists of the disturbance footprints associated with BHP Billiton Iron Ore existing mines and infrastructure, third-party existing iron ore mines and infrastructure and existing non-mining land uses. The spatial extent of the Existing Development Scenario is shown in Figure 13, and assumptions made about each of the inputs are discussed further below.

As shown in Figure 13, the Strategic Proposal's Cumulative Existing Development Case is based on the following:

- Existing BHP Billiton Iron Ore mining operations. Yandi, Mining Area C, Newman (including mines at Mount Whaleback and Eastern Ridge), Jimblebar (including Wheelarra) and their associated rail infrastructure. The disturbance represents the extent of ground disturbance to date and may be less than that approved under existing environmental approvals;

- Existing third-party iron ore operations[3]. Existing third-party operations included:
  - Rio Tinto's (including joint ventures with Hamersley Iron, Hamersley HMS and Robe River Mining Co.) Brockman Syncline 4, Hope Downs 1, Hope Downs 4, Marandoo, Mount Tom Price, West Angelas, Western Turner Syncline Section 10 and Yandicoogina (including Junction Central, Junction SE, Junction SW and Oxbow); and
  - Fortescue Metals Group's Cloudbreak and Christmas Creek.

  Note that Rio Tinto's Nammuldi Silvergrass Mine and FMG's Solomon Iron Ore Mine were not included as an input in the Cumulative Existing Development Scenario as they are located more than 50 km away from BHP Billiton Iron Ore mining tenures, and were not considered likely contribute to potential cumulative impacts from BHP Billiton Iron Ore's operations.
- Existing non-mining impacts. A review of available datasets determined that the Geoscience Australia Global Map 2001 (1:1,000,000) dataset was the best publicly available source of data for the cumulative impact assessment. Data for roads, power lines, airfields, railway yards, human settlements and built-up areas were obtained from this dataset. Existing non-mining impacts do not include grazing or agricultural activities.

7.4.2 30% CONCEPTUAL DEVELOPMENT SCENARIO

This scenario represents the extent of cumulative direct disturbance within the Project Definition Boundary at a future point when 30% of BHP Billiton Iron Ore's identified operations are operating concurrently (a reasonably foreseeable level of operation). In addition to BHP Billiton Iron Ore's developments, the scenario includes reasonably foreseeable third-party iron ore mines. It also includes the Existing Development Scenario. The spatial extent of the 30% Conceptual Development Scenario is shown in Figure 14, and assumptions made about each of the inputs into this scenario are discussed further below.

[3] Existing third-party operations considered were those that had been approved and were underway as at June 2012 (the time of referral of the Strategic Proposal under the EP Act), within a 50 km buffer of BHP Billiton Iron Ore tenure.

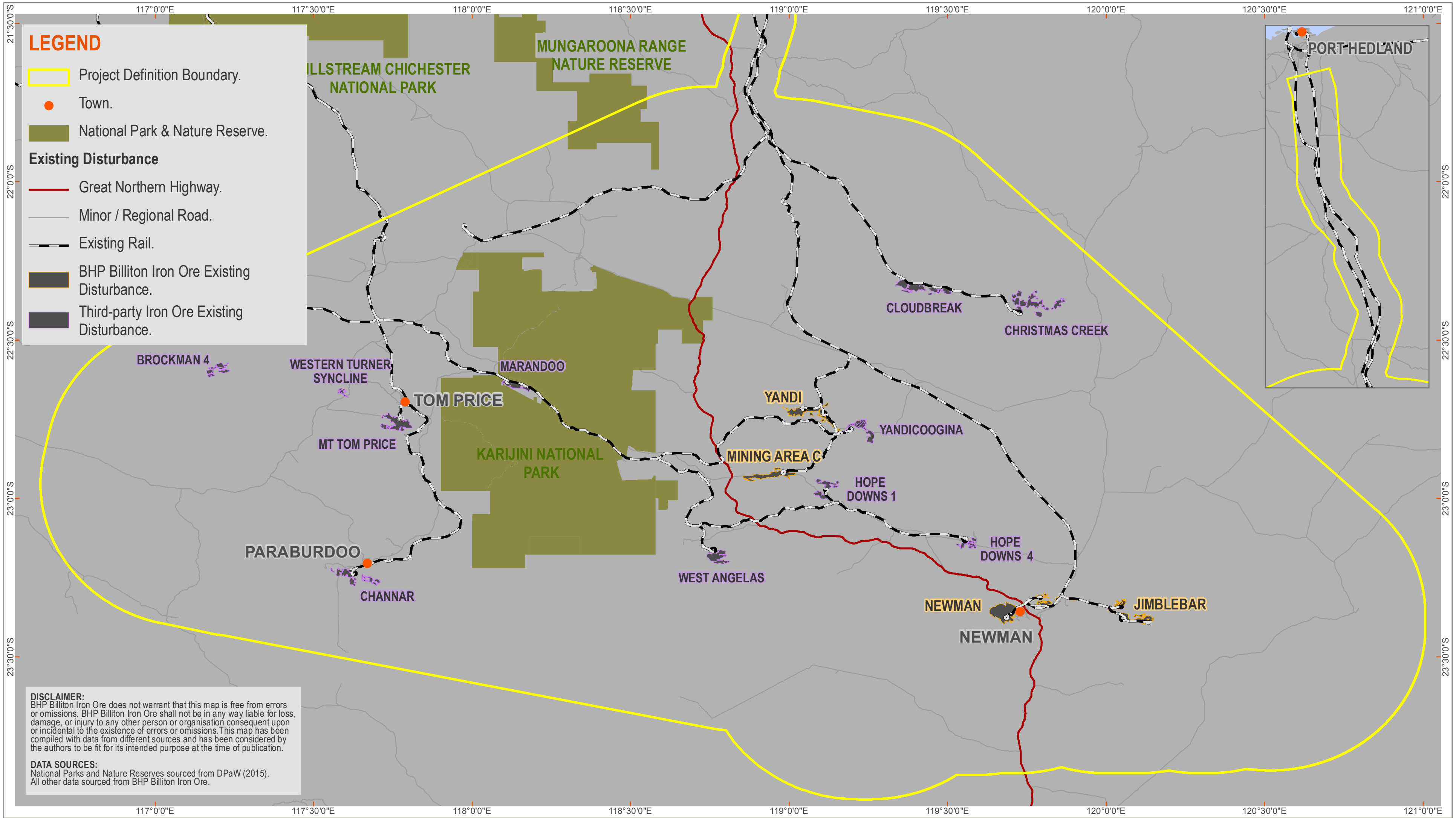


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Figure 13 Existing Development Scenario

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The 30% Conceptual Development Scenario is a future scenario that is conceptual only and designed as a tool for assessment of the potential cumulative impacts of the Strategic Proposal. The conceptual footprints for these future development scenarios are based on the following:

- Existing Development Scenario as described above in Section 7.4.1;
- BHP Billiton Iron Ore's 30% Conceptual Development Scenario, which includes the following future operations: Jimblebar (expansion), Jinidi, Marillana, Mining Area C (expansion), Mudlark, Munjina/Upper Marillana, Newman (expansion), South Flank and Yandi;
- Reasonably foreseeable future third-party iron ore operations derived from publicly available data for projects referred or approved by the EPA. It included projects or components of projects already approved but not yet implemented or only partially implemented and projects referred to the EPA as at September 2014[4]. The disturbance footprint does not take into account any expansions that third-party operators may propose to undertake in the future, where this information has not yet been referred to the EPA. The following reasonably foreseeable third-party operations were included in the 30% Conceptual Development:
  - Rio Tinto's (including joint ventures with Hamersley Iron, Hamersley HMS and Robe River Mining Co.) Brockman Syncline 4, Hope Downs 1, Hope Downs 4, Koodaideri, Marandoo, West Angelas, Western Turner Syncline, Western Turner Syncline Stage 2, Yandicoogina (Junction SE, Junction SW and Oxbow, Pocket and Billiard South);
  - Fortescue Metal Group's Cloudbreak (expansion), Christmas Creek (expansion), Mindy Mindy and Nyidinghu;
  - Atlas Iron's Davidson's Creek;
  - Australian Premium Iron Management's Hardey;
  - Iron Ore Holdings' Iron Valley;
  - Brockman Resources' Marillana; and
  - Hancock Prospecting's Roy Hill Stage 1 and Roy Hill Stage 2.

Note that FMG's Solomon Iron Ore Mine expansions were not included as an input in the Cumulative 30% Conceptual Development Scenario as the expansions are located more than 50 km away from BHP Billiton Iron Ore mining tenures and were not considered likely to contribute to potential cumulative impacts.

7.4.3 FULL CONCEPTUAL DEVELOPMENT SCENARIO

This scenario is based on the production rate associated with full conceptual development of BHP Billiton Iron Ore's future identified projects being in concurrent operation. It builds on the 30% Conceptual Development Scenario, so it includes the Existing Development Scenario and reasonably foreseeable third-party iron ore mines; however, it does not include future long-term predictions about third-party iron ore mines or other land uses as this information is not publically available. The Full Conceptual Development Scenario, while useful for assessing impacts at regional and long-term scales, is conservative in nature with respect to BHP Billiton Iron Ore's development footprints as concurrent operation of all BHP Billiton Iron Ore future identified projects is unlikely.

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[4] Reasonably foreseeable third-party operations considered were those that are located within 50 km of BHP Billiton Iron Ore tenure and those that had been referred or approved as at September 2014 but had not commenced by June 2012 (commenced third-party operations were included under the Existing Development Scenario). BHP Billiton Iron Ore is aware of other iron ore projects referred since that cut-off date; however, these additional disturbance areas are considered unlikely to change the outcomes of the cumulative impact assessment.

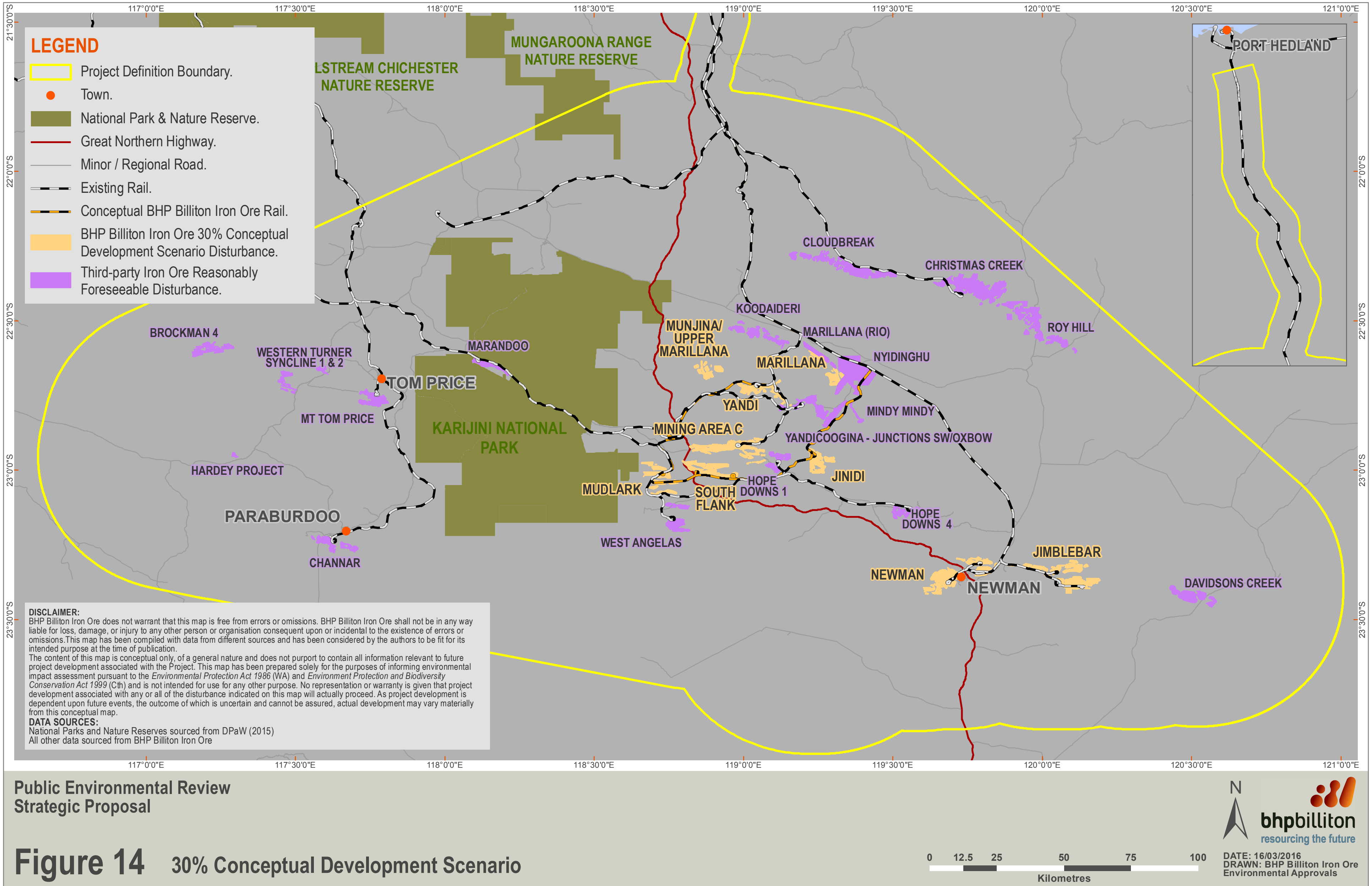

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Figure 14 30% Conceptual Development Scenario

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The spatial extent of the Full Conceptual Development Scenario is shown in Figure 15, and assumptions made about each of the inputs into this scenario are discussed further below.

The Full Conceptual Development Scenario is a future scenario that is conceptual only and designed as a tool for assessment of the potential cumulative impacts of the Strategic Proposal. The conceptual footprints for this future development scenario are based on the following:

- Existing Development Scenario as described above in Section 7.4.1;
- reasonably foreseeable future third-party iron ore operations as described for the 30% Conceptual Development Scenario in Section 7.4.2; and
- BHP Billiton Iron Ore Full Conceptual Development Scenario, which includes the following future operations: Caramulla, Coondiner, Gurinbiddy, Jimblebar (expansion), Jinidi, Marillana, Mindy, Mining Area C (expansion), Ministers North, Mudlark Well, Munjina/Upper Marillana, Newman (expansion), Ophthalmia/Prairie Downs, Rocklea, Roy Hill, South Flank, Tandanya and Yandi (expansion).

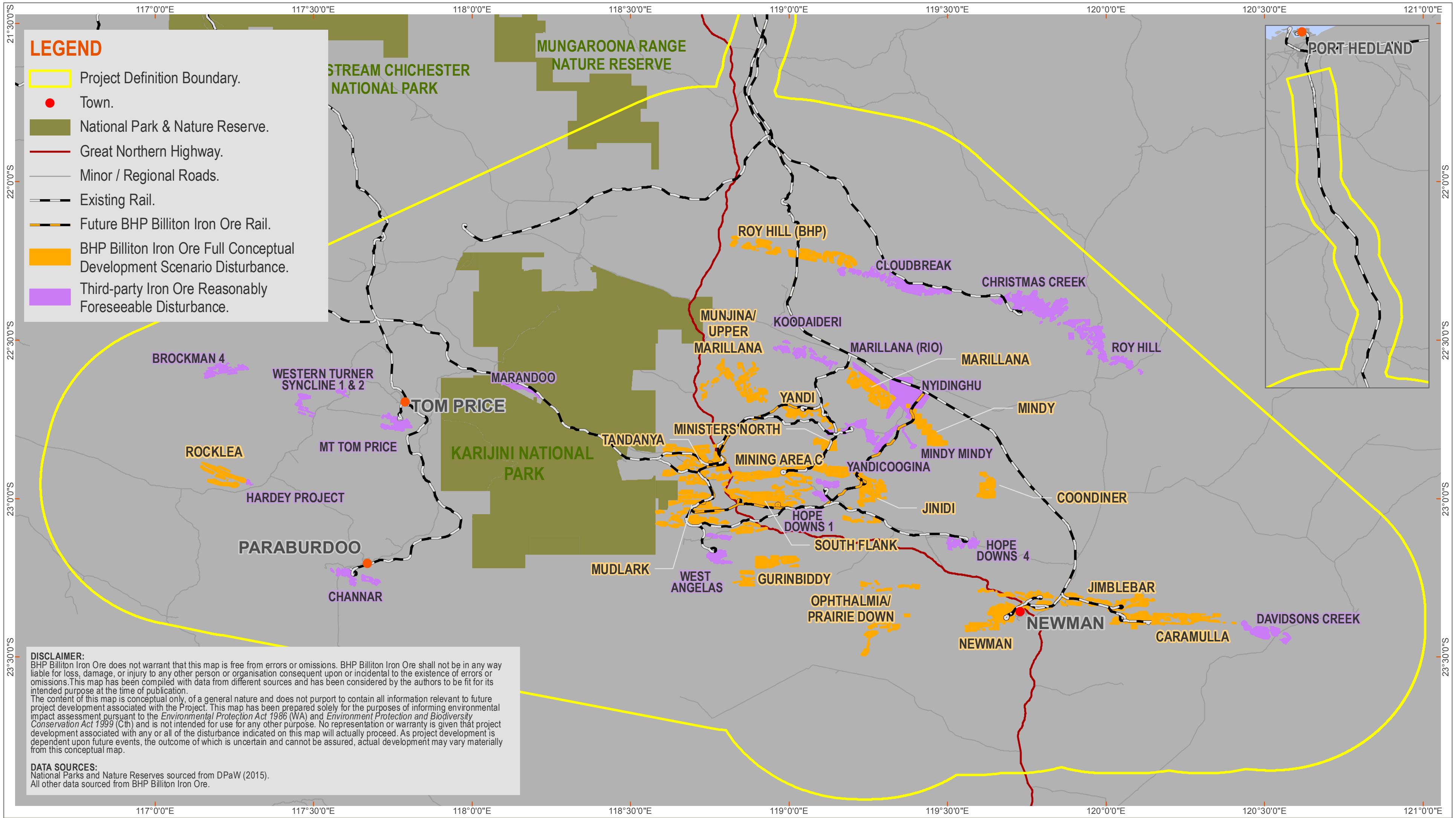
7.5 Baseline Data and Cumulative Impact Assessments

BHP Billiton Iron Ore has commissioned over 350 individual baseline environmental surveys over the last decade. Supporting studies have been undertaken by BHP Billiton Iron Ore internal specialists and by a wide consultancy base. This wealth of baseline knowledge supports BHP Billiton Iron Ore’s confidence in the rigour and robustness of the environmental impact assessment undertaken for the PERSP and the effectiveness of its approach to managing potential impacts of the Strategic Proposal to an acceptable level. In addition to BHP Billiton Iron Ore baseline data, an extensive review of publicly available data was collated and included in this PERSP.

BHP Billiton Iron Ore has also undertaken a number of factor-based regional cumulative impact assessments to support this PERSP. Using a spatial GIS analysis, relevant direct and indirect impacts have been considered where sufficient knowledge was available to support an analysis. The assessments covered:

- Land (biodiversity);
- Water (surface and groundwater);
- People (heritage and amenity);
- Air (air quality specifically considering particulates and greenhouse gases); and
- Integrating Factors (closure and rehabilitation).

The impact assessments provide an understanding, using the best information available, of potential impacts to key factors arising from the Strategic Proposal. The key inputs and studies undertaken for the PERSP are listed in Table 9 and described in detail in the relevant sections in Chapter 8 (as per Table 9).



Public Environmental Review
Strategic Proposal

Figure 15 Full Conceptual Development Scenario

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resourcing the future

DATE: 16/03/2016
DRAWN: BHP Billiton Iron Ore Environmental Approvals

Table 9: Studies undertaken for the PERSP

THEME	FACTOR	STUDIES AND INPUTS	DESCRIPTION	SECTION
Land	Flora and Vegetation	Consolidated Vegetation Mapping (Onshore 2014)	Flora and vegetation mapping and data that spatially consolidates 162 historical datasets from 2004 to 2013 from across BHP Billiton Iron Ore tenure within the Project Definition Boundary to provide information on vegetation associations and vegetation condition.	8.1.3
		Beard Vegetation Associations Mapping (Beard 1975)	The vegetation associations contained within the Pilbara bioregion and Project Definition Boundary (within and outside of BHP Billiton Iron Ore tenure) are mapped, to provide information on the regional extent of vegetation in the area.	8.1.3
		CSIRO model - Using community-level modelling to map levels of biodiversity significance in the Pilbara Bioregion (Appendix 3)	Report includes a modelled output for biodiversity significance across the Pilbara bioregion, which has been used to evaluate potential impacts to regional biodiversity.	8.1.2
		Flora and Fauna Screening Assessment (Appendix 4)	A screening assessment of direct (clearing) impacts of all proposed projects (BHP Billiton Iron Ore and third-party iron ore projects referred as of September 2014) on mapped locations of conservation-significant flora species from within the Project Definition Boundary. For flora, the assessment used data from BHP Billiton Iron Ore and data supplied by DPaW in December 2015.	8.1.3
	Terrestrial Fauna	Consolidated Fauna Habitat Mapping (Biologic 2014)	Fauna habitat mapping and data that spatially consolidates historical datasets from across BHP Billiton Iron Ore tenure to provide information on fauna habitat types for conservation-significant fauna. Aligns largely with vegetation mapping developed for the Consolidated Vegetation Mapping project described above.	8.1.4
		CSIRO model - Using community-level modelling to map levels of biodiversity significance in the Pilbara Bioregion (Appendix 3)	Report includes a modelled output for biodiversity significance across the Pilbara bioregion, which has been used to evaluate potential impacts to regional biodiversity.	8.1.2
		Flora and Fauna Screening Assessment (Appendix 4)	A screening assessment of direct (clearing) impacts of all proposed projects (BHP Billiton Iron Ore and third-party iron ore projects referred as of September 2014) on mapped locations of conservation-significant fauna species from within the Project	8.1.4

THEME	FACTOR	STUDIES AND INPUTS	DESCRIPTION	SECTION
			Definition Boundary. For fauna, the assessment used data from BHP Billiton Iron Ore and data supplied by DPaW in December 2015 and birdlife Australian and Western Australian museum in January 2016.	
		Short-range Endemic Invertebrate Review and Risk Assessment (Appendix 5)	Investigates land system suitability for SRE habitats across the Pilbara bioregion and also provides mapping of SRE habitat suitability across BHP Billiton Iron Ore tenure within the Project Definition Boundary, based on Consolidated Vegetation Mapping and Consolidated Fauna Habitat Mapping. Assesses the risk to SRE habitat suitability at a tenure and regional scale based on BHP Billiton Iron Ore's Full Conceptual Development Scenario.	8.1.4
	Subterranean Fauna	Description of Regional Subterranean Fauna (Appendix 6)	Describes the regional diversity and distribution of troglofauna and stygofauna within a study area surrounding Strategic Proposal tenure and maps areas that may support significant subterranean fauna communities in the Pilbara bioregion. This report has been used to evaluate impacts from the Strategic Proposal on subterranean fauna.	8.1.5
	Landforms	Land and Visual Impact Risk Assessment (Appendix 8)	Provides an assessment of impacts to landscape character types, land systems and landforms.	8.1.6
	Terrestrial Environmental Quality	Ecohydrological Change Assessment (ECA) (Appendix 7)	Mapped and assessed acid metalliferous drainage (AMD) source potential using BHP Billiton Iron Ore's Full Conceptual Development Scenario. This output has been used to inform potential impacts to terrestrial environmental quality.	8.1.6
Water	Hydrological Processes and Inland Waters Environmental Quality	Groundwater and surface water modelling undertaken as part of the ECA (Appendix 7)	The ECA provides a description of the regional hydrology of the Pilbara, allowing assessment of ecohydrological units and key environmental assets that are potentially subject to hydrological change from the Strategic Proposal. The study boundary for the ECA (referred to as the Ecohydrology Study Boundary) is based on surface water and groundwater catchments within which the Strategic Proposal tenure are located; however, this boundary does not include Rocklea. The ECA also provides a case study on the Ethel Gorge Stygobiont Community TEC, a key asset.	8.2.2
Air	Air Quality and Atmospheric Gases	Particulate modelling undertaken as part of the Cumulative Air Quality Assessment (Appendix 9)	Sensitive receptors (to air particulates) were identified within the Project Definition Boundary, and the air emissions were modelled and examined for potential exposure at these receptors.	8.4

THEME	FACTOR	STUDIES AND INPUTS	DESCRIPTION	SECTION
		Greenhouse gas assessments	GHG emissions (by fuel type) were analysed for some of BHP Billiton Iron Ore's existing mines. The data on fuel usage, together with the tonnage of material moved, was used to generate a weighted average fuel use per tonne of material moved. This was used to calculate BHP Billiton Iron Ore's GHG emissions for the three development scenarios, i.e. Existing Development Scenario, 30% Conceptual Development Scenario and Full Conceptual Development Scenario.	8.4
People[1]	Amenity	LVRA (Appendix 8)	The assessment of potential impacts to landscape and visual amenity values as a result of the Strategic Proposal was undertaken for areas within the Project Definition Boundary.	8.3.4
		Cumulative Noise Impact Assessment (Appendix 10)	A regional-scale model comprising noise typically emitted from mining operations, for each of the development scenarios, was generated, with sensitive receptors identified and noise levels at these receptors assessed.	8.3.5
	Heritage	Aboriginal heritage assessments	Large-scale archaeological and ethnographic surveys have been conducted across BHP Billiton Iron Ore tenure to identify places of cultural significance. As this is sensitive information, it is managed internally at BHP Billiton Iron Ore and informs planning and development processes. Heritage surveys are ongoing, as is consultation with the relevant Native Title Group(s).	8.3.2
		European heritage assessments	Literature reviews and desktop database searches have informed BHP Billiton Iron Ore's understanding of the European heritage values that may exist within the areas within the Project Definition Boundary.	8.3.3

1. Human health is not considered to be a relevant environmental factor for the Strategic Proposal. Refer to Section 8.3 for further detail.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework (EPA 2015b) to determine whether the proposal can meet the EPA objectives for each environmental factor.

Impact assessment has been considered, as applicable, for direct impacts at a local and regional scale. Direct impacts are considered to be those that are attributable to the proposed mining-related activity and that occur within the Project Definition Boundary. These might include impacts as a result of land clearing.

Indirect impacts are considered to be facilitated by, but not directly caused by, an activity. For example, generating dust that impacts surrounding vegetation condition is an indirect impact.

Local impacts are considered to be impacts at the scale of a local activity, e.g. the zone of impact of a particular activity or a particular operation (e.g. an existing or future mine).

Regional impacts are considered to be impacts at the scale of the bioregion or of the entire distribution of a species.

Cumulative impacts are considered to be the aggregate impacts (both direct and indirect) on a given receptor, ecosystem, or population centre of past, present and reasonably foreseeable future activities as a result of both BHP Billiton Iron Ore and third-party operations. Analysis of the cumulative impacts considers BHP Billiton Iron Ore's impact in relation to existing impacts and other iron ore mining operations in the Pilbara. These have been discussed in the context of known regional threats in the Pilbara where applicable to the environmental factor.

The scope of the cumulative impact assessment, as defined in terms of the development scenarios, activities, environmental themes and factors considered, spatial boundary and impacts, is summarised in Table 10.

Table 10: Summary of the key elements of the PERSP impact assessment

SCOPE OF IMPACT ASSESSMENT	DESCRIPTION
Conceptual Development Scenarios	• Existing Development Scenario (as at 2013) • 30% Conceptual Development Scenario, including reasonably foreseeable future third party mines • Full Conceptual Development Scenario, including reasonably foreseeable future third party mines Refer to Section 7.4 for a description of these development scenarios.
Activities	• Existing mining and non-mining activities and land use. • Reasonably foreseeable future third party iron ore projects. • BHP Billiton Iron Ore future proposed operations under this Strategic Proposal.
Environmental themes and factors	Land • Flora and vegetation • Terrestrial fauna • Subterranean fauna • Landforms • Terrestrial environmental quality Water • Hydrological processes • Inland waters environmental quality People • Aboriginal heritage • European heritage

<table>
<tr><th>SCOPE OF IMPACT ASSESSMENT</th><th>DESCRIPTION</th></tr>
<tr><td></td><td>Visual Amenity
Noise
Air
Air quality
Atmospheric gases
Integrating factors
Rehabilitation and decommissioning
Offsets</td></tr>
<tr><td>Spatial boundary</td><td>Varies with each environmental factor, including:
The Project Definition Boundary
The Pilbara bioregion as presented in the Interim Biogeographic Regionalisation for Australia (DSEWPaC 2012a)
The area for which baseline data were available
The presence of existing or reasonably foreseeable future development projects (including BHP Billiton Iron Ore projects)
Study areas specific to each factor where applicable.</td></tr>
<tr><td>Impacts</td><td>Impacts are considered from a cumulative perspective, where applicable, or attributed solely to BHP Billiton Iron Ore activities, as appropriate. Impacts are considered at local and regional spatial scales, as well as from direct and indirect impacts. It should be noted that there are third party impacts from non-mining activities have not been considered.
The type of impact considered, due to relevance of proposed activities and potential environmental impact, is summarised for each factor below:
<table>
<tr><th>FACTOR</th><th>SOURCE OF DIRECT IMPACTS</th><th>INDIRECT IMPACTS</th></tr>
<tr><td>Flora and Vegetation</td><td>Removal of vegetation</td><td>Altered Water Regimes
Fire*
Weeds*</td></tr>
<tr><td>Fauna</td><td>Removal of vegetation and fauna habitats
Permanent modification of landforms</td><td>Surface water and groundwater alteration
Contamination of soils and water*
Introduced species*
Dust deposition*
Interactions with mining-related infrastructure*
Fire*</td></tr>
<tr><td>Subterranean Fauna</td><td>Removal of habitat
Groundwater alteration of stygofauna habitat</td><td>Groundwater alteration of troglofauna habitat*;
Vibration*
Presence of modified landforms*
Contamination of soils and water*</td></tr>
<tr><td>Terrestrial Environmental Quality</td><td>Permanent modification of landforms</td><td>Generation of AMD
Increase in erosion potential</td></tr>
<tr><td>Hydrological</td><td>Groundwater drawdown to</td><td>Groundwater drawdown</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Scope of Impact Assessment</th><th>Description</th></tr>
<tr><td></td><td>
<table>
<tr><td>Processes</td><td>stygofauna habitat.</td><td>to flora and vegetation and habitat.
• Changes to groundwater quality
• Reduced surface water availability
• Surplus water management (incl. quality)
• Pit Lakes*</td></tr>
<tr><td>Air Quality and Atmospheric Gases</td><td>Construction and mining operation activities.</td><td>• Generation of dust
• Generation of greenhouse gas emissions</td></tr>
<tr><td>Amenity</td><td>Permanent modification of landforms.</td><td>• Generation of dust
• Generation of noise</td></tr>
<tr><td>Heritage</td><td>Physical disturbance to heritage sites.*</td><td></td></tr>
<tr><td>Human Health</td><td>See Air Quality and Atmospheric Gases, and Amenity.</td><td></td></tr>
<tr><td>Rehabilitation and decommissioning</td><td>• Permanent modification of landforms
• Permanent modification of vegetation and habitat</td><td>• Contamination of soils and water*
• Impacts to hydrological processes*</td></tr>
</table>
* These impacts have not been included in the quantitative cumulative impact assessment but are included in the discussion of impacts, under the relevant section heading in Chapter 8. It should be noted that no reasonably foreseeable third-party impacts from non-mining related activities have been considered.</td></tr>
</table>

7.6 Indirect Impacts of Secondary Actions

BHP Billiton Iron Ore has also considered potential indirect impacts of secondary actions associated with implementation of the Strategic Proposal. Secondary actions are those that are not directly related to the scope of the Strategic Proposal but that may arise as a result of development undertaken for the Strategic Proposal. Consideration of these indirect impacts was undertaken to understand the broader potential implications of the Strategic Proposal for the environment and was a requirement of the Commonwealth Strategic Assessment process.

In considering indirect impacts, BHP Billiton Iron Ore identified that it's port operations at Port Hedland may require changes to throughput volumes as a result of the implementation of Derived Proposals under the Strategic Proposal. Changes to throughput volumes would therefore be a secondary action.

Port operations consist of iron ore receiving, processing, stockpiling and ship loading at Finucane Island (west) and Nelson Point (east), located on opposite sides of the Port Hedland Inner Harbour. Over the life of the Strategic Proposal, there may be Derived Proposals that could contribute to an increase in iron ore throughput and that may require upgrades of existing port infrastructure and the potential expansion of BHP Billiton Iron Ore's existing port operations.

In 2012, BHP Billiton Iron Ore received approval from the then DSEWPaC and the Western Australian EPA for its proposed Outer Harbour project in Port Hedland (EPBC Referral 2008/4159 and Ministerial Statement 890). This approval allowed for the development of additional jetties and berths outside the existing harbour.

In early 2013, BHP Billiton Iron Ore announced that the Outer Harbour development will be deferred beyond its short-term planning horizon as the Company focuses on maximising the potential capacity from the Inner Harbour and capitalising on infrastructure from previous investment. While BHP Billiton Iron Ore's dual harbour strategy includes both development of the Outer Harbour and optimising the Inner Harbour, development of the Outer Harbour project is not currently expected in the short term.

In considering the potential indirect impacts from future secondary actions, BHP Billiton Iron Ore has examined reasonably foreseeable growth scenarios for its port operations. Currently, the most likely port development scenario includes further expansion of BHP Billiton Iron Ore's Inner Harbour infrastructure followed (if required) by development of an Outer Harbour. The reasonably foreseeable secondary actions that could arise from this scenario include:

- increased throughput, including shipping movements (using existing infrastructure);
- upgrades or expansion of existing infrastructure (e.g. Inner Harbour); and
- development of new infrastructure (e.g. Outer Harbour).

The reasonably foreseeable impacts from these secondary actions include:

- change in dust emissions;
- change in noise emissions;
- change to terrestrial flora;
- impacts to marine flora and fauna from dredging;
- impacts to marine fauna from ship movements;
- changes in water use;
- impacts to terrestrial fauna;
- change in greenhouse gas emissions;
- spills or contamination; and
- social impacts (traffic, amenity etc.).

For BHP Billiton Iron Ore's future port operations, a number of potential indirect impacts that may arise from the Strategic Proposal have already been considered via existing approvals. These include approvals that are in place for BHP Billiton Iron Ore's proposed Outer Harbour development and upgrades to existing Inner Harbour infrastructure.

The environmental impacts expected to arise from the proposed Outer Harbour development have previously been assessed through state and Commonwealth legislative processes and include dredging, shipping movements, dust and social impacts. Where changes may be proposed in future to BHP Billiton Iron Ore's approved Outer Harbour development, BHP Billiton Iron Ore will review these changes and, where necessary, seek amendments to existing approvals or new approvals as required.

The extent of changes to BHP Billiton Iron Ore's Inner Harbour infrastructure is expected to be confined to the existing operating footprints on Nelson Point and Finucane Island. Where a change in the footprint is anticipated (e.g. additional marine infrastructure), BHP Billiton Iron Ore will seek the necessary changes to existing environmental approvals or, where required, seek new approvals under relevant state and Commonwealth legislation.

The primary environmental impacts anticipated from any future increase in throughput from BHP Billiton Iron Ore's Inner Harbour infrastructure relate to potential changes in dust and noise emissions. BHP Billiton Iron Ore will continue to work with the relevant government agencies and the community to manage dust and noise emissions from its operations and will continue to seek the necessary environmental approvals.

Based on the above, BHP Billiton Iron Ore considers that potential indirect impacts outside the Project Definition Boundary from implementation of the Strategic Proposal have been identified and have either been adequately addressed through existing approvals or will be assessed through future approvals where required.

7.7 Outputs

The impact assessment of activities required for construction and operation of the various conceptual development scenarios has allowed a regional understanding of:

- the baseline environmental condition of the Pilbara;
- the key regional threats; and
- the potential impacts to the environment.

The impact assessment outputs were then reviewed in consideration of BHP Billiton Iron Ore's environmental management objectives (Table 2) to determine whether the mitigated response will result in significant impact to the environment. The significance of environmental impact has been assessed based on the EPA Environmental Guideline 9 (EPA 2015b). These results form the basis of the assessment in Chapter 8.

If the EPA considers that a proposal can meet all of its objectives (the proposal falls in the lower zone in Figure 16, i.e. is below the likely significance threshold), then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives (the proposal falls in the centre zone), then its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives (the proposal falls in the top zone), then its effect on the environment is likely to be unacceptable.

In preparing and analysing impacts from this Strategic Proposal, BHP Billiton Iron Ore applied the EPA's significance framework to determine whether the proposal meets the EPA's objectives for each environmental factor. The outcomes of this analysis are presented in the Summary of Assessment Outcomes for each environmental factor in the relevant sections in Chapter 8 and in Table 84 in Section 9.2, which presents a consolidated summary of the impact assessment outcomes for all environmental factors.

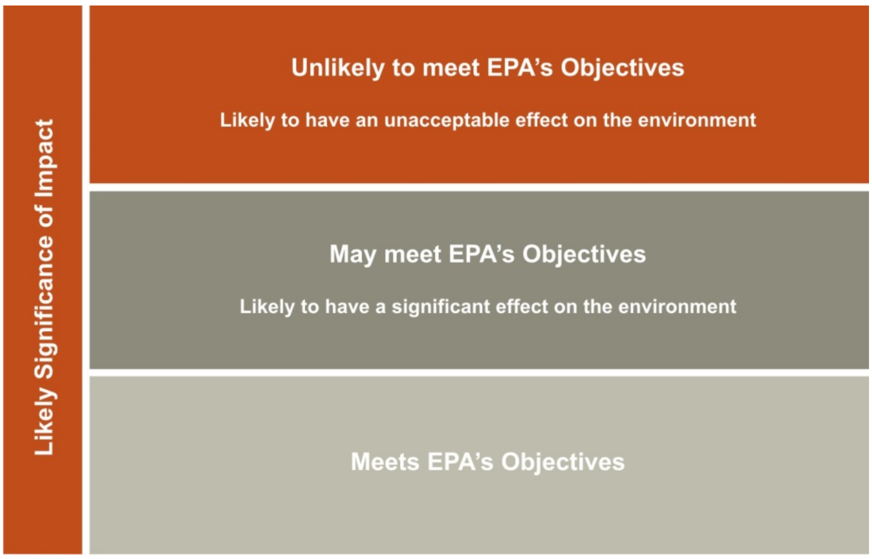

Figure 16: EPA's significance framework

The mitigation measures for each Environmental Factor are compiled as a 'mitigation toolkit' for environmental factors or themes (as applicable). The appropriate management response can be selected from the toolkit to achieve the outcome-based objectives, providing flexibility and adaptability in the management approach. The management measures developed are not exhaustive, and additional measures will be developed over the life of BHP Billiton Iron Ore's operations and will be revisited in detail at the Derived Proposal stage.

7.8 Peer Review

BHP Billiton Iron Ore recognises the benefit of independent peer review as part of the Strategic Proposal process, given the proposal's large geographical and temporal scale. To ensure a high level of confidence in the technical work underpinning the impact assessment, BHP Billiton Iron Ore established a peer review panel, made up of ten recognised local, national and international expert reviewers with a collective purpose to ensure that the key documents and overall strategy underpinning the impact assessment met leading practice. The peer review panel commented on a range of matters, including:

- the overall impact assessment approach, the methods and management approaches. Reviewers had technical, regulatory and strategic environmental assessment experience; and
- technical merit. This group of experts focused on species of conservation significance and the EPA factors, including assessment of the cumulative impacts, modelled outcomes and mitigation approaches.

Peer reviewers relevant to the state and Commonwealth impact assessment process are identified in Table 11.

Table 11: Peer review panel

MEMBER	EXPERTISE RELEVANT TO THE STRATEGIC PROPOSAL
Dr Larry Canter [5]	Cumulative impact assessment and global perspective on best practice
Mr Warren Tacey	Regulatory experience, strategic assessment experience and local context
Dr Chris Moran[4]	Cumulative impact assessment modelling
Dr Mike Bamford	Northern Quoll (*Dasyurus hallucatus*)
Dr Rick Southgate	Greater Bilby (*Macrotis lagotis*)
Dr Mark Fitzgerald	Pilbara Olive Python (*Liasis olivaceus barroni*)
Dr Kyle Armstrong	Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)
Dr Eddie van Etten	Hamersley Lepidium (*Lepidium catapycnon*)
Dr Doug Brown	Hydrology
Dr Libby Mattiske	Ecohydrology, regulatory experience and local context
Mr Garth Humphreys	Subterranean fauna and short range endemics

[5] Larry Canter (USA) and Chris Moran were involved during the formative stages of the strategic assessment to provide high-level, strategic guidance on cumulative impact assessment and modelling.

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8 IMPACT ASSESSMENT RESULTS

8.1 Land

8.1.1 INTRODUCTION

The EPA theme Land, as outlined in Environmental Assessment Guideline 8 (EPA 2015a), includes consideration of the following factors, which are considered within this Section:

- flora and vegetation;
- terrestrial fauna (including vertebrate fauna and short-range endemic (SRE) invertebrate fauna);
- subterranean fauna;
- landforms; and
- terrestrial environmental quality.

8.1.1.1 ENVIRONMENTAL FACTOR OBJECTIVES

Table 12 outlines the environmental objectives from both the EPA and BHP Billiton Iron Ore. As outlined in Section 4.2.1, BHP Billiton Iron Ore will demonstrate that the EPA's objective is met by meeting the Company objective.

Table 12: EPA and BHP Billiton Iron Ore environmental factor objectives for Land

FACTOR	EPA OBJECTIVE (EPA 2015A)	BHP BILLITON IRON ORE OBJECTIVE[1]
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	BHP Billiton Iron Ore shall mitigate risks to flora and vegetation from its activities to an acceptable level.
Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	BHP Billiton Iron Ore shall mitigate risks to terrestrial fauna from its activities to an acceptable level.
Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	BHP Billiton Iron Ore shall mitigate risks to subterranean fauna from its activities to an acceptable level.
Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms and soils.	BHP Billiton Iron Ore shall mitigate risks to landforms from its activities to an acceptable level.
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.	BHP Billiton Iron Ore shall mitigate risks to terrestrial environmental quality from its activities to an acceptable level.

1. 'Acceptable level' is defined as per the EPA's significance framework in Environmental Assessment Guideline 9 (EPA 2015b); thus BHP Billiton Iron Ore considers an 'acceptable level' of impact to be a level of residual impact that meets the EPA's objectives for that environmental factor.

8.1.1.2 KEY LEGISLATION AND GUIDANCE

As discussed in Section 7.1, BHP Billiton Iron ore has addressed relevant legislation, policy and guidance for each factor. These are detailed in Appendix 1, Table 1.1. BHP Billiton Iron Ore recognises that new legislation, guidance and policies, such as the proposed Biodiversity Conservation Bill 2015, may have implications for environmental management during implementation of the Strategic Proposal. BHP Billiton Iron Ore will consider new environmental legislations as part of the Derived Proposal process.

8.1.1.3 LAND AND BIODIVERSITY MANAGEMENT TOOLKIT

BHP Billiton Iron Ore has a suite of mitigation measures (a 'mitigation toolkit') that can be selected from in order to achieve the outcome-based objectives for environmental factors relating to Land. The management measures presented are not exhaustive. Additional measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied in line with BHP Billiton Iron Ore's adaptive management approach. BHP Billiton Iron Ore's management toolkit for land and biodiversity is presented in Figure 17.

Management measures from the Land and Biodiversity Management toolkit are provided as examples for each of the environmental factors relating to land throughout Section 8.1.

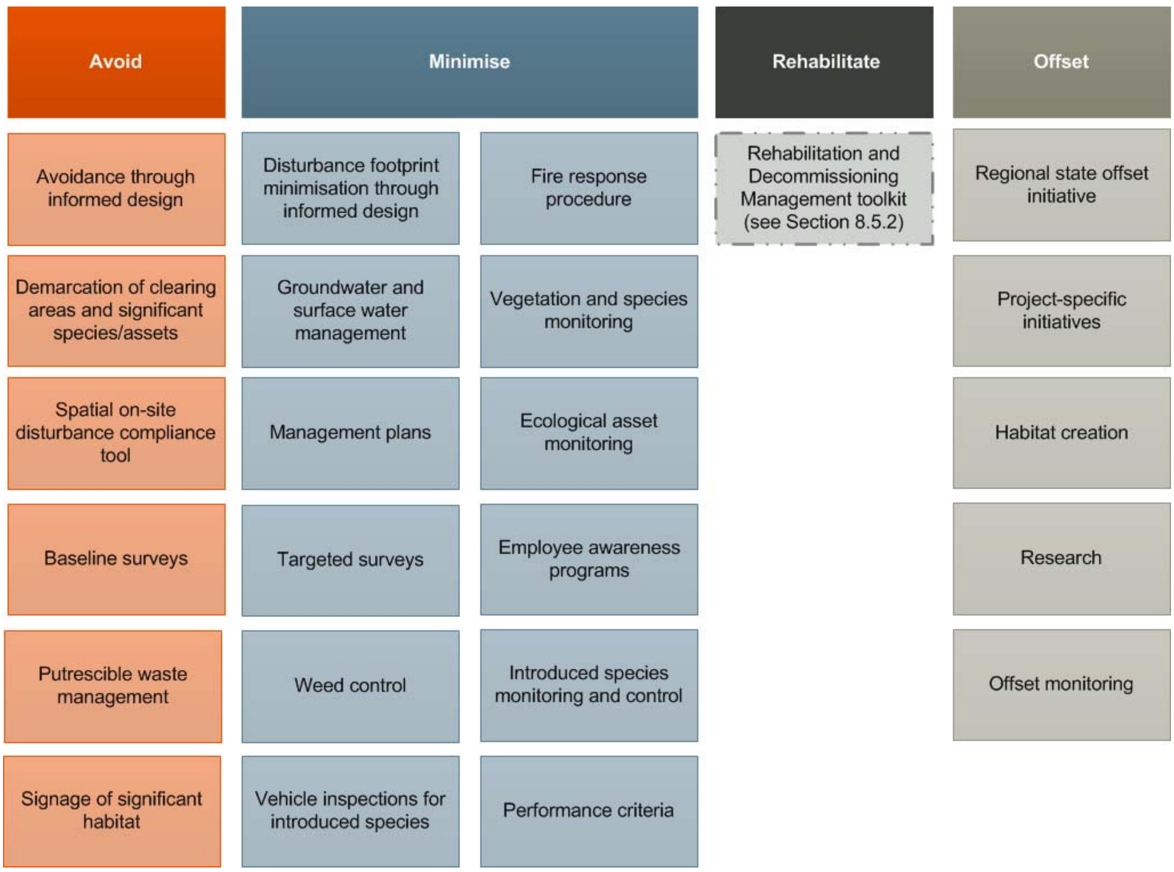


Figure 17: BHP Billiton Iron Ore's Land and Biodiversity Management toolkit

8.1.2 REGIONAL BIODIVERSITY VALUES ASSESSMENT

This section describes the nature and extent of impacts from the Strategic Proposal to conservation estate, TECs and PECs, and Pilbara region biodiversity within the Project Definition Boundary. These are recognised as key assets as discussed in Section 6.2.

8.1.2.1 EXISTING ENVIRONMENT

Conservation Estate

The national and regional planning framework for the systematic development of a comprehensive, adequate and representative (CAR) National Reserve System is provided by the Interim Biogeographic Regionalisation of Australia (IBRA) (DSEWPaC 2012a). The IBRA is endorsed by all levels of government as a key tool for identifying land for conservation under Australia's Strategy for the National Reserve System (Natural Resource Policies and Program Committee 2009). IBRA regions and subregions relevant to the Project Definition Boundary are described in Section 5.1.

The Conservation Commission controls the vesting of Western Australia's terrestrial conservation estate. DPaW manages lands on behalf of the Conservation Commission. In Western Australia, the following categories under the *Conservation and Land Management Act 1984* (CALM Act) are considered part of the National Reserve System: national park, nature reserve and conservation park. Section 5(1)(g) and 5(1)(h) reserves under the CALM Act may be part of the National Reserve System, depending on their statutory purpose. Collectively, these categories comprise 'protected areas' under the formal conservation reserve system. These reserves have a wide variety of purposes but are normally related to recreation, wildlife conservation, infrastructure and historical features. One national park (Karijini National Park) and one nature reserve (Mungaroona Range Nature Reserve) occur within the Project Definition Boundary (Figure 18), however the Strategic Proposal does not include development within these areas. The other primary conservation reserves in the Pilbara bioregion are Millstream Chichester National Park and Cane River Conservation Park, located outside of the Project Definition Boundary.

Nature reserves and conservation parks are established for wildlife and landscape conservation; and while some recreation activities may be permitted, restrictions usually apply. National parks are similar to nature reserves but are less restricted in terms of public access and recreation.

Also, a number of areas within the Project Definition Boundary were excluded from pastoral leases in 2015, becoming Unallocated Crown land (UCL). The Department of Lands has direct responsibility for all UCL, with the Department of Parks and Wildlife responsible for the management of weeds, feral animals and fire prevention. Consultation with DPaW indicates that these areas have been excluded from pastoral leases so as to contribute to the CAR National Reserve System. However, they are not as yet formally recognised as conservation estate and formal vesting and management arrangement has yet to be completed by the state government for these areas. For the purposes of this PERSP, they have been considered to be 'proposed conservation reserves'. Exclusion areas within the Project Definition Boundary include:

- Juna Downs Station exclusion areas;
- Marillana Station exclusion area;
- Hillside Station exclusion area; and
- Roy Hill Station exclusion area.

BHP Billiton Iron Ore granted or pending mining tenure covers part of the Juna Downs pastoral station exclusion area.

In addition to the above, consultation with DPaW indicates that a small area surrounding Weeli Wolli Spring is proposed to be managed for conservation purposes. Weeli Wolli Spring is also a PEC and has been considered within this section.

Conservation estate and proposed conservation reserves within the Project Definition Boundary are shown in Figure 18.

One of the aims of the Pilbara Biodiversity Survey undertaken by the Department of Conservation and Land Management (now DPaW) between 2002 and 2007 was to 'include a quantitative assessment of the existing reserve system to identify gaps in its coverage of species and communities and identify areas that efficiently improve its comprehensiveness, adequacy and representativeness' (McKenzie et al. 2009). Key findings of the survey were:

- The existing conservation reserve system includes examples of a wide variety of the substrates and geomorphic units that characterise the Pilbara (McKenzie et al. 2009), and it supports populations of 16 of the 18 small ground mammals recorded during this study (Gibson & McKenzie 2009). If the reserves are managed to maintain the integrity of the communities associated with them, they should be adequate to allow ground-dwelling mammals to persist in the region (Gibson & McKenzie 2009). McKenzie and Bullen (2009) recommended that well-developed riparian sites in 'range country' should be included in conservation reserves, in particular Weeli Wolli Spring, which is regionally unique for microbats and is important for the persistence of at least two bat species in the region.
- The low level of variation in occurrence of terrestrial bird species suggests that the existing large conservation reserves in the Pilbara are likely to contain most of the variation expected in terrestrial bird communities of the Pilbara, although the Weeli Wolli catchment requires better protection (Burbidge et al. 2010). The key impacts to terrestrial bird species were identified as grazing by introduced herbivores, altered and inappropriate fire regimes, shrubby weeds, introduced grasses and, in some places, mining infrastructure (Freudenberger et al. 1997; McKenzie et al. 2009).
- There have been no known extinctions of herpetofauna in the Pilbara despite over a century of anthropogenic disturbances, and there is no evidence of a regional decline in any taxon (Doughty et al. 2011). The existing conservation reserves contain the vast majority of herpetofaunal taxa known from the Pilbara bioregion, but a number of restricted skinks do not occur in any of the existing conservation reserves, with *Lerista nevinae* being highlighted as a species particularly at risk (Doughty et al. 2011). Impacts of grazing stock and feral animals in riparian areas, the scale of intense fire events and the impact of cane toads have been highlighted as key threats to the conservation of herpetofauna (reptiles) assemblages in the Pilbara (Doughty et al. 2011). *Lerista nevinae* is not known to have been recorded within the Project Definition Boundary.

Threatened Ecological Communities and Priority Ecological Communities

A threatened ecological community (TEC) is one that has been endorsed by Western Australia's Environment Minister as being subject to processes that threaten to destroy or significantly modify it across much of its range (DEC 2007). The proposed Biodiversity Conservation Bill 2015 formally recognises TECs, which may be listed as 'critically endangered', 'endangered' or 'vulnerable'. Most TECs are either naturally restricted in distribution or were once widespread but now occur as remnants in the landscape. A widespread ecological community may be listed as a TEC if information indicates that significant and widespread threats are active across its range. BHP Billiton Iron Ore recognises TECs as Tier 1 assets (refer to Section 6.2).

Possible TECs that do not meet the stringent survey criteria for the assessment of TECs are added to DPaW's Priority Ecological Communities (PECs) lists under Priorities 1, 2 or 3. Ecological communities that are adequately known, that are rare but not considered to be threatened, that meet criteria for 'near threatened', or that have been recently removed from the threatened list are placed in Priority 4 (DEC 2007). BHP Billiton Iron Ore recognises PECs as Tier 2 assets (refer to Section 6.2).

Two TECs and eight PECs occur within the Project Definition Boundary as shown in Figure 18 and described in Table 13. Note that the buffers are shown at the regional scale.

Pilbara Biodiversity

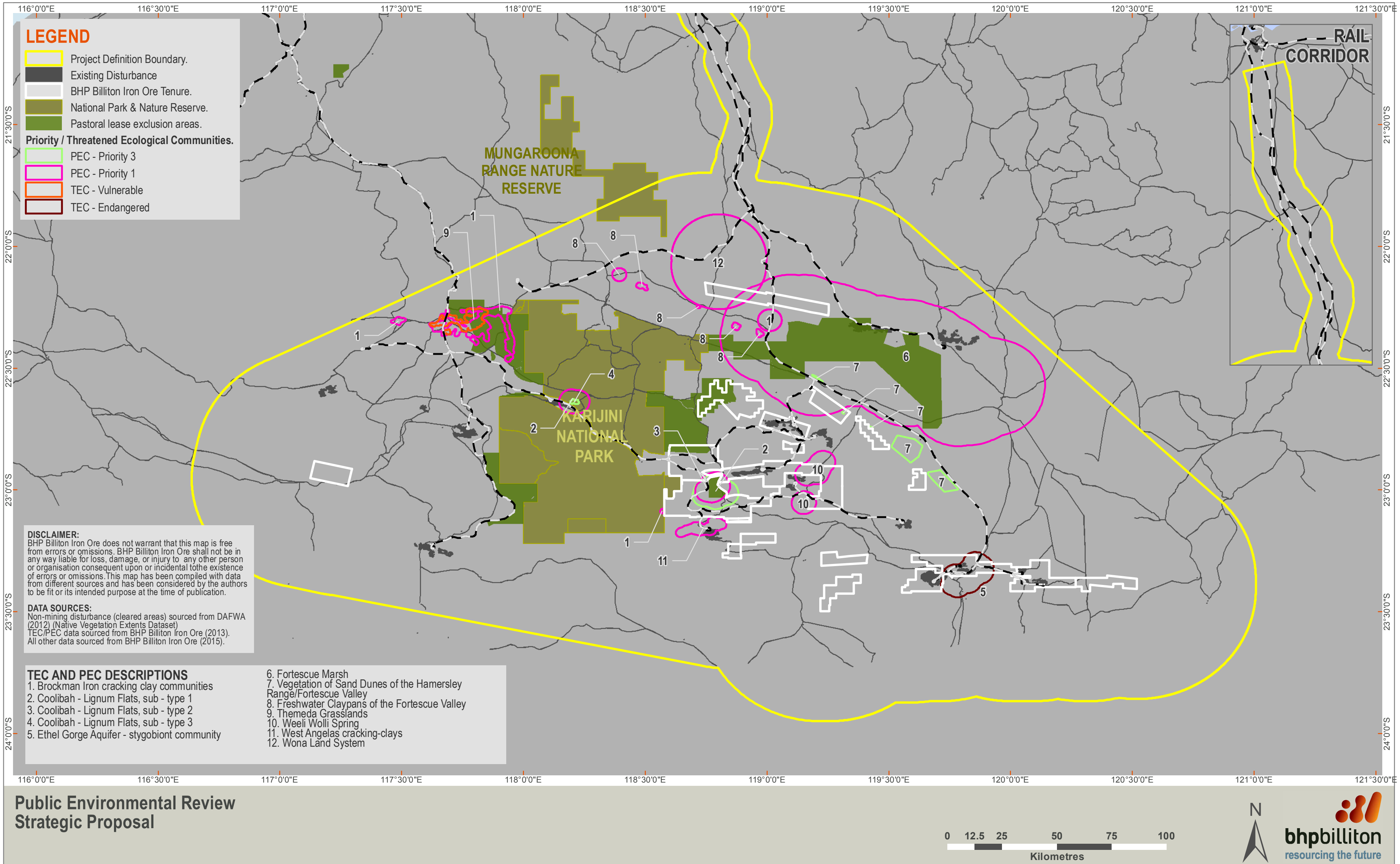
In 2012, BHP Billiton Iron Ore commissioned CSIRO to undertake an assessment of spatial patterns in the distribution of biodiversity and the associated levels of biodiversity significance across the Pilbara bioregion (Appendix 3). Data for this project was sourced from BHP Billiton Iron Ore's corporate database, the DPaW and the Atlas of Living Australia partners. Modelled biodiversity significance (defined as the potential for a given location to harbour a concentration of species narrowly distributed beyond that location, due to natural patterns of endemism or anthropogenic habitat degradation) is mapped in Figure 19. It shows the relative significance of locations in terms of the natural level of uniqueness, or endemism, they are expected to have exhibited prior to human disturbance. Darker green areas have a lower significance for biodiversity than yellow or red areas. The clouded areas indicate higher levels of uncertainty.

As illustrated in Figure 19, most of the area within the Project Definition Boundary contains outputs that are ‘more certain’ than other areas in the Pilbara bioregion. This is likely due to the high level of survey work that has been undertaken to support environmental impact assessments for mining activities.

Areas of predicted highest biodiversity significance within the Project Definition Boundary include:

- the lowlands to the northwest of Karijini National Park, coinciding with the Themeda grasslands TEC (see Table 13);
- the Fortescue Valley and parts of the Fortescue River, in particular the Fortescue Marsh (Priority 1 PEC);
- lowland areas, such as Coondewanna Flats (Priority 1 and 3 PECs) and Weeli Wolli Creek (Priority 1 PEC), and parts of Marillana Creek, particularly within the Upper Marillana/Munjina Strategic Proposal tenure;
- northern and western parts of the Hamersley Range, adjacent to and within Karijini National Park, increasing around Mount King, Mount Frederick and Mount McCleod;
- high peaks throughout the central and western Hamersley Range, including Mount Meharry (in Karijini National Park), Mount Robinson, Mount Hildich and Mount Ella;
- parts of the Hancock Range in the eastern area of Karijini National Park and Mount Windell, which is adjacent to the national park boundary; and
- Ophthalmia Range, including Mount Newman and around Ethel Gorge.

Many of the above areas of higher biodiversity significance are located within Karijini National Park or coincide with TECs and PECs described in Table 13. Development within Karijini National Park is not proposed and is not within the scope of the Strategic Proposal.



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Strategic Proposal

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DATE: 25/02/2016
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Figure 18 Conservation estate and Priority and Threatened Ecological Communities within the Project Definition Boundary

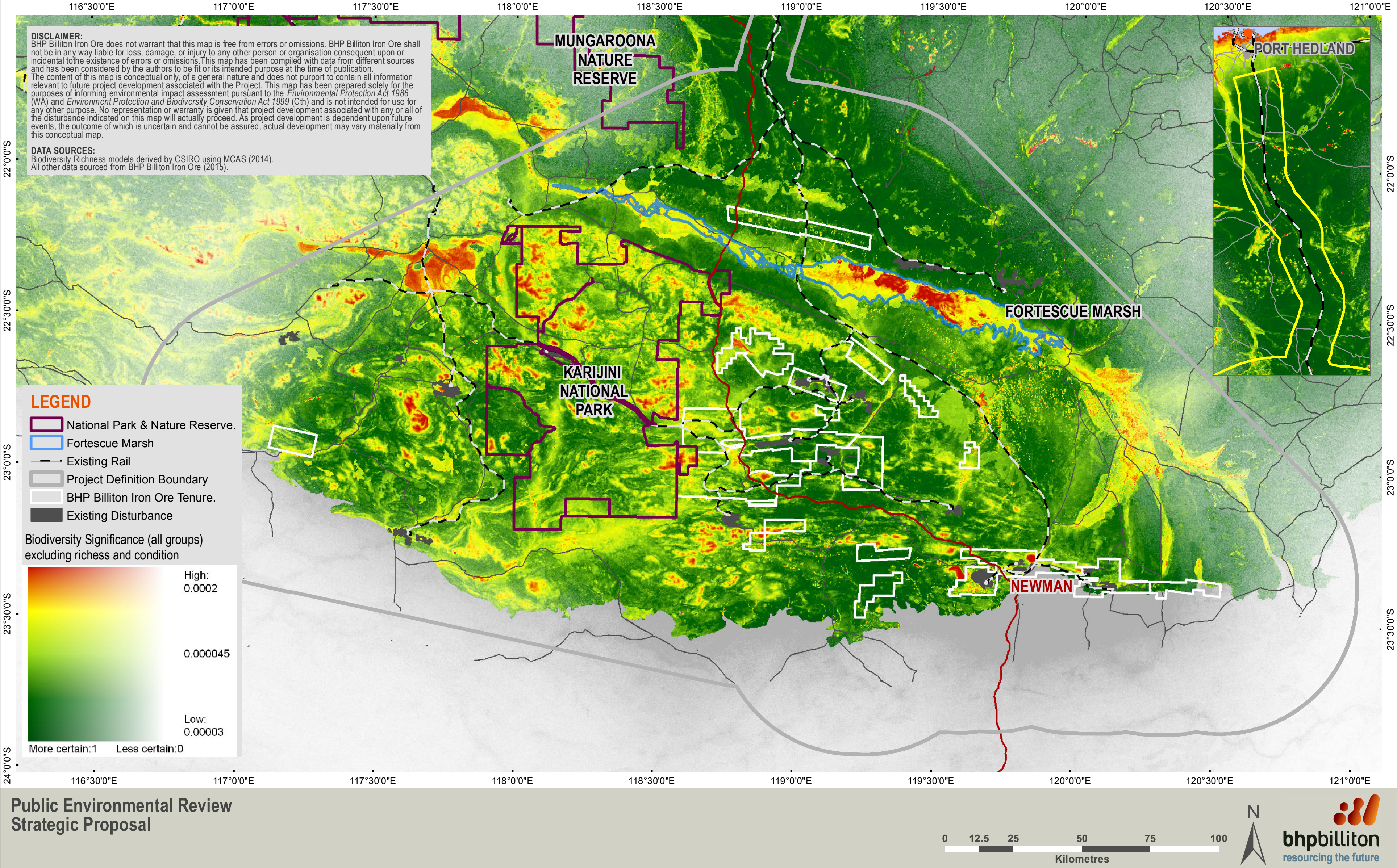

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Figure 19 Spatial prediction of biodiversity significance for the Pilbara bioregion

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Table 13: Threatened and Priority Ecological Communities within the Project Definition Boundary

Community and Description[1]	Status[1]
Threatened Ecological Communities	
Themeda Grasslands: *Themeda* grasslands on cracking clays (Hamersley Station, Pilbara). Grassland plains dominated by the perennial *Themeda* (kangaroo grass) and many annual herbs and grasses.	Vulnerable
Ethel Gorge Aquifer Stygobiont Community: The shallow alluvial and calcrete aquifers of Ethel Gorge support a unique and diverse stygofauna assemblage, the Ethel Gorge Aquifer Stygobiont Community (Endangered). The area supports riparian woodland communities with potential groundwater dependence. Further information on this TEC is provided in Section 8.2.	Endangered
Priority Ecological Communities	
Fortescue Marsh (Marsh Land System): Fortescue Marsh is an extensive, episodically inundated samphire marsh at the upper terminus of the Fortescue River and the western end of the Koodaideri Hills. It is regarded as the largest ephemeral wetland in the Pilbara. It is a highly diverse ecosystem with fringing mulga woodlands (on the northern side), samphire shrublands and groundwater-dependent riparian ecosystems. It is an arid wetland utilised by waterbirds and supports a rich diversity of restricted aquatic and terrestrial invertebrates. Recorded locality for night parrot and bilby and several other threatened vertebrate fauna. Endemic *Eremophila* species, populations of priority flora and several near-endemic and new-to-science samphire species. Further information on this PEC is provided in Section 8.2.	Priority 1
Freshwater Claypans of the Fortescue Valley: Freshwater claypans downstream of the Fortescue Marsh and the Goodiadarrie Hills on Mulga Downs Station. Important for waterbirds, invertebrates and some poorly collected plants. *Eriachne* spp., *Eragrostis* spp. grasslands. Unique community has few coolibah. Further information on this PEC is provided in Section 8.2.	Priority 1
Brockman Iron Cracking Clay Community of the Hamersley Range: Rare tussock grassland dominated by *Astrebla lappacea* (not every site has presence of *Astrebla*) in the Hamersley Range, on the Brockman Land System. Tussock grassland on cracking clays derived in valley floors, depositional floors. This is a rare community, and the landform is rare. Known from near West Angeles, Newman, Tom Price and the boundary of Hamersley and Brockman stations.	Priority 1
Four Plant Assemblages of the Wona Land System: A system of basalt upland gilgai plains with tussock grasslands occurs throughout the Chichester Range in the Millstream Chichester National Park, in Mungaroona Range Nature Reserve and on adjacent pastoral leases. There are a series of community types identified within the Wona Land System gilgai plains that are considered susceptible to known threats, such as grazing, or have constituent rare or restricted species. Subtype Mitchell grass (*Astrebla* spp.) plains on gilgai occur within the Project Definition Boundary.	Priority 3
Weeli Wolli Spring Community: Weeli Wolli Spring riparian woodland and forest associations are unusual as a consequence of the composition of the understorey. The sedge and herbfield communities that fringe many of the pools and associated water bodies along the main channels of Weeli Wolli Creek have not been recorded from any other wetland site in the Pilbara. The spring and creekline area are also noted for their relatively high diversity of stygofauna, and this is probably attributable to the large-scale calcrete and alluvial aquifer system associated with the creek. The valley of Weeli Wolli Spring also supports a very rich microbar assemblage, including a threatened species. Further information on this PEC is provided in Section 8.2.	Priority 1

West Angelas Cracking Clays: Open tussock grasslands of *Astrebla pectinata*, A. *elymoides*, *Aristida latifolia*, in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt-derived cracking-clay loam depressions and flowlines.		Priority 1
Vegetation of Sand Dunes of the Hamersley Range/Fortescue Valley (previously Fortescue Valley Sand Dunes): These red linear iron-rich sand dunes lie on the Divide Land System at the junction of the Hamersley Range and Fortescue Valley, between Weeli Wolli Creek and the low hills to the west. A small number are vegetated with *Acacia dictyophleba* scattered tall shrubs over *Crotalaria cunninghamii*, *Trichodesma zeylanicum* var. *grandiflorum* open shrubland. The dunes are regionally rare, small and fragile and highly susceptible to threatening processes.		Priority 3
Coolibah-lignum Flats: *Eucalyptus victrix* over *Muehlenbeckia* community. Woodland or forest of *Eucalyptus victrix* (coolibah) over thicket of *Duma florulenta* (lignum) on red clays in run-on zones. Associated species include *Eriachne benthamii*, *Themeda triandra*, *Aristida latifolia*, *Eulalia aurea* and *Acacia aneura*.	Subtype 1: Coolibah and mulga (*Acacia aneura*) woodland over lignum and tussock grasses on clay plains (Coondewanna Flats and Wanna Munna Flats).	Priority 3
	Subtype 2: Coolibah woodlands over lignum (*Duma florulenta*) over swamp wandiree (Lake Robinson is the only known occurrence).	Priority 1
	Subtype 3: Coolibah woodland over lignum and silky browntop (*Eulalia aurea*) (two occurrences known on Mt Bruce Flats)	Priority 1

1. Descriptions and status as per DPaW Priority Ecological Communities List (6 June 2015) and Threatened Ecological Communities List endorsed by the Minister for the Environment (25 June 2015).

8.1.2.2 POTENTIAL IMPACTS

Conservation estate, TECs and PECs within the Project Definition Boundary have the potential to be directly or indirectly impacted by the Strategic Proposal, in conjunction with potential for cumulative impacts from other existing and/or reasonably foreseeable activities. These areas are recognised for their biodiversity values; therefore, the potential impacts to these areas are the same as those described for flora and vegetation (identified in Section 8.1.3.2), terrestrial fauna (identified in Section 8.1.4.2), subterranean fauna (identified in Section 8.1.5.2) and hydrological processes and inland waters environmental quality (identified in Section 8.2.2.2).

The assessment in this section refers to direct impacts from land clearing only, and includes modelling of cumulative impacts from BHP Billiton Iron Ore and third parties over time.

Indirect impacts to vegetation (which may include Conservation estate, TECs and/or PECs) include the establishment of weeds through ecological processes such as competition with individual native flora thereby changing the flora assemblage, changing fire patterns, and hydrological change. These are discussed in further detail in Section 8.1.3.

8.1.2.3 MITIGATION

Applying the tiered system described in Section 6.2 to prioritise and rank environmental assets and communities, TECs are placed within the highest tier (Tier 1). Impacts to TECs and will therefore be mitigated to achieve the management objective in relation to conservation estate.

BHP Billiton Iron Ore objectives for Tier 1 assets are made relevant on an individual proposal basis through a series of defined outcomes for key environmental assets and their biophysical elements. As part of the Derived Proposal stage, outcomes for Tier 1 assets will be embedded in asset management plans.

For Tier 1 assets, BHP Billiton Iron Ore will define the mitigation measures, to be applied from the land and biodiversity management toolkit (Figure 17) within management plans. Examples of these mitigation tools are provided throughout Sections 8.1.3 to 8.1.6.

Regional management plans (including the toolkits) embed the concept of adaptive management and continuous improvement in BHP Billiton Iron Ore's management approach. This ensures that mitigation measures, outcomes, indicators and thresholds can be adapted to take account of regulatory changes, new guidance, improved knowledge and analysis of monitoring data. The adaptive management approach is discussed in detail in Part D.

BHP Billiton Iron Ore has applied this management approach, including management measures from the land and biodiversity management toolkit to effectively manage potential impacts to the Ethel Gorge Aquifer Stygobiont Threatened Ecological Community (Case Study 6). BHP Billiton Iron Ore has been operating within the Ethel Gorge Aquifer TEC buffer since the early 1980s (Table 44). The application of BHP Billiton Iron Ore's regional management approach has been applied for the Ethel Gorge TEC and the regional management approach has been applied in the Ecohydrological studies and change assessments (Appendix 7).

The Derived Proposal process allows the consideration of environmental change in the future, including changes to boundaries of the existing conservation estate, PECs and TECs and the gazettal of new conservation estate.

8.1.2.4 SIGNIFICANCE OF IMPACTS

Impacts to Conservation Estate

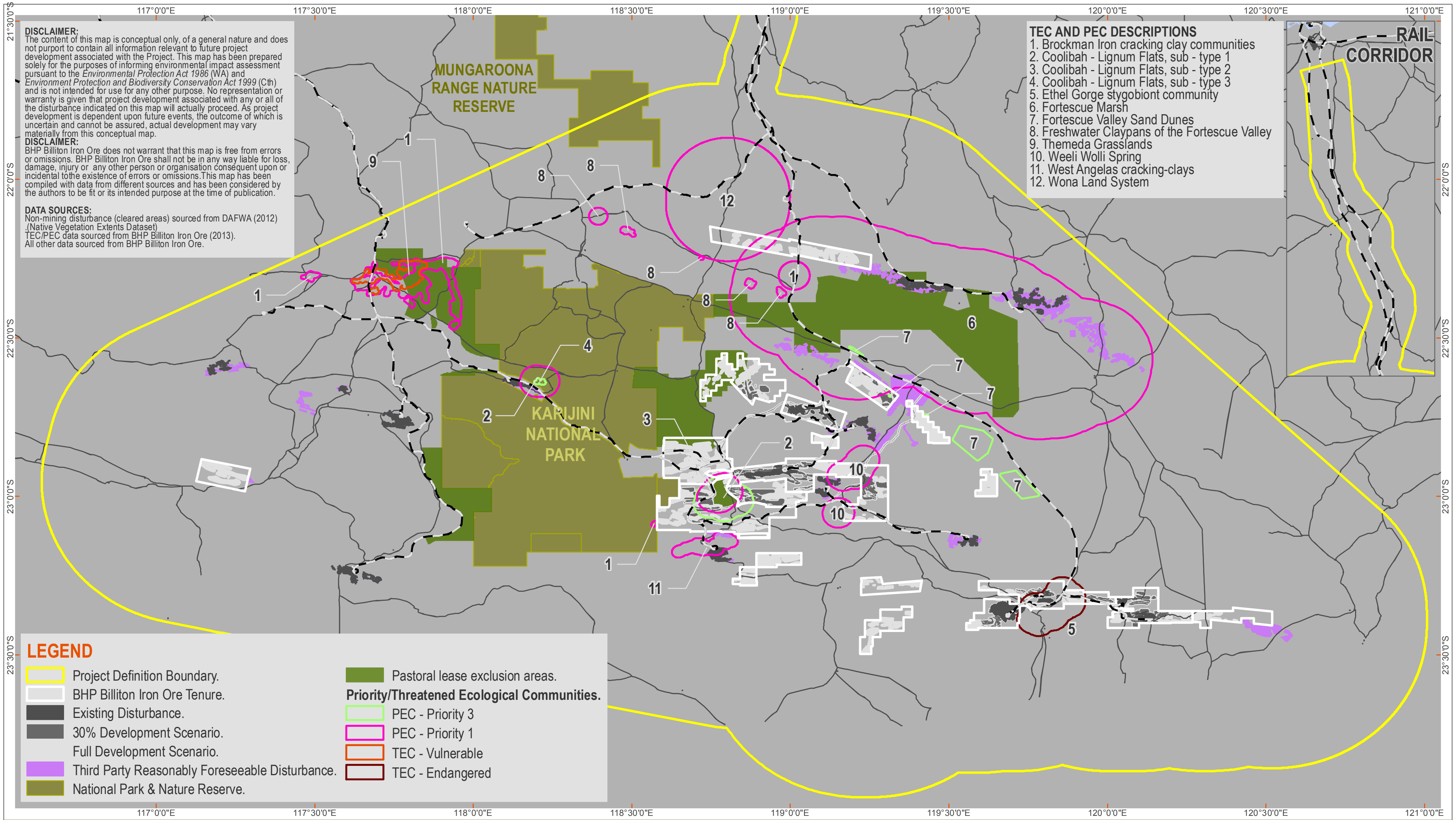
Figure 20 shows the direct footprint associated with reasonably foreseeable third-party iron ore mines and BHP Billiton Iron Ore's 30% Conceptual Development Scenario and Full Conceptual Development Scenario. The Full Conceptual Development Scenario footprint does not overlap with Karijini National Park or Mungaroona Range Nature Reserve; therefore, no direct impacts from the Strategic Proposal are expected to these areas.

Some areas of proposed conservation reserves will be directly impacted by the Strategic Proposal, with the Full Conceptual Development Scenarios footprint (Upper Marillana / Munjina, Tandanya and Mudlark) being located within areas excluded from Juna Downs pastoral station as shown in Figure 20. BHP Billiton Iron Ore's Full Conceptual Development Scenarios footprint does not overlap any other areas of proposed conservation reserve. Some third party footprints including Rio Tinto Iron Ore's proposed development footprint near Koodaideri and Fortescue Metals Cloudbreak footprint overlaps pastoral areas excluded in 2015 for conservation. The Derived Proposal process enables the outcomes and resolution of land management to be applied to projects at the Derived Proposal stage.

Indirect impacts to Karijini National Park could potentially occur under the Full Conceptual Development Scenario with Mudlark Well and Tandanya mining areas occurring adjacent to the National Parks' south eastern boundary. No indirect impacts are expected to occur to Mungaroona Nature Reserve, as the reserve is in excess of 120km from the nearest footprint in the Full Conceptual Development Scenario.

The highest risk indirect impacts to Karijini National Park have been assessed to be from unmitigated dewatering associated with mining activity, and the reduction of visual amenity experienced from Mt Meharry. Karijini National Park has been assessed as a key receptor in Section 8.2.2.1 when assessing hydrological processes and ecohydrological change as part of the Strategic Proposal. The assessments findings, displayed in Table 44, consider that the likelihood of drawdown extending to the National Park is low owing to hydrogeological complexity, geological structure, topographic differences and separation distance.

Visual amenity from Mt Meharry has been assessed in the Landscape and Visual Resource Assessment Study (Appendix 8) and displayed in Figure 65. Visual amenity may be impacted, at Mt Meharry in particular, because of its elevation and large viewshed. The study noted however that implementation of the mitigation hierarchy throughout the closure process and increased vegetative cover following rehabilitation will reduce impacts, to an acceptable level, to visual amenity over time.



Public Environmental Review
Strategic Proposal

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DATE: 25/02/2016
DRAWN: BHP Billiton Iron Ore Environmental Approvals

Figure 20 Conservation reserves, TECs and PECs relative to the development scenarios

Impacts to Threatened Ecological Communities and Priority Ecological Communities

Figure 20 shows the direct footprint associated with reasonably foreseeable third-party iron ore mines and BHP Billiton Iron Ore's 30% Conceptual Development Scenario and Full Conceptual Development Scenario. As Figure 20 shows, the Full Conceptual Development Scenario footprint overlaps with the following areas:

- Ethel Gorge Aquifer Stygobiont Community TEC;
- Vegetation of Sand Dunes of the Hamersley Range/Fortescue Valley PEC; and
- Coolibah-lignum Flats PEC Subtype 1: Coolibah and mulga woodland over lignum and tussock grasses on clay plains (Coondewanna and Wannamunna flats).

Table 14 outlines the proportion of TECs and PECs that may be directly impacted by the Strategic Proposal. Existing or reasonably foreseeable third-party footprints do not overlap with any TEC or PEC boundaries, so they have not been included in the analysis. The impacts to each of the conservation-significant ecological communities are discussed below.

Table 14: Potential direct Strategic Proposal impacts to conservation significant ecological communities

Ecological Community	Proportion of TECs and PECs potentially directly impacted by BHP Billiton Iron Ore^		
	Existing Development Scenario (%)	30% Conceptual Development Scenario (%)	Full Conceptual Development Scenario (%)
Ethel Gorge Aquifer Stygobiont Community	1.78 (0.11% pits only)	4.85 (0.12% pits only)	10.31 (4.08% pits only)
Vegetation of Sand Dunes of the Hamersley Range/Fortescue Valley	None	0.06	0.06
Coolibah-lignum Flats Subtype 1: Coolibah and mulga woodland over lignum and tussock grasses on clay plains (Coondewanna and Wannamunna flats)	None	2.12	2.24

^ Note that as there was no overlap from third party footprints in these Ecological Communities, the impacts presented are attributable to BHP Billiton Iron Ore's conceptual footprint(s) only.

The highest potential impact is to the Ethel Gorge aquifer stygobiont community, for which approximately 10% of the ecological community occurs within BHP Billiton Iron Ore's Full Conceptual Development Scenario footprint. This potential direct impact is 4.08% when only the area covered by pits is considered in the calculations, and the pit areas are considered more relevant to this subterranean ecological community as the pits excavate deeper into the soil, and thus have a greater potential to impact the subterranean environment where the stygobiont communities are found. Note that the direct impacts from groundwater drawdown dominate the impact to this TEC. Impacts of groundwater drawdown are discussed in Section 8.2.2. Effective management of the groundwater regime at Ethel Gorge will maintain stygofauna habitat and is one of the principle considerations in BHP Billiton Iron Ores regional water management planning for the Eastern Pilbara (Case Study 6).

A very small proportion of the Vegetation of Sand Dunes of the Hamersley Range/Fortescue Valley PEC may be impacted by the Strategic Proposal from the 30% Conceptual Development Scenario onwards. Two occurrence of this ecological community are located within the Marillana mining hub, which is within the scope of the Strategic Proposal. These two occurrences are isolated and distinct occurrences of 4.4 ha and 3.07 ha respectively 25 km from the main area of the PEC and account for 0.06 % of the Priority 3 PEC. The removal of these two isolated occurrences of this community will not impact on the integrity or continued ecological functioning of the community.

BHP Billiton Iron Ore's Full Conceptual Development Scenario footprint remains 1.9 km from the main body of the PEC (vegetated sand dune community). The community is not ground or surface water dependant and is unlikely to be subject to indirect impacts. Section 6.2 outlines the approach to reviewing the individual PEC to determine whether it should remain in Tier 2 or whether it should be elevated to Tier 1 to ensure that the management objective is met. Given that the potential direct impact is predicted to be 0.06% of the extent of this PEC and that there are not considered to be any indirect impacts, BHP Billiton Iron Ore considers that with the application of management as a Tier 1 Asset the potential impacts to this PEC can be acceptably managed.

A small proportion of the Coolibah-lignum Flats PEC Subtype 1, which occurs within Coondewanna Flats, is predicted to be directly impacted by the Strategic Proposal, at 2.12% for the 30% Conceptual Development Scenario and increasing slightly to 2.24% for the Full Conceptual Development Scenario. The subtype of this PEC also occurs at Wannamunna Flats, which is approximately 35 km east-southeast of Coondewanna Flats, within the Project Definition Boundary but well outside of the Full Conceptual Development Scenario footprint. Direct impact to the PEC Subtype 1 occurs within the proposed Mudlark hub on the south west edge of the PEC. Given that this PEC subtype occurs in two locations and the small proportion of direct impact to the extent of the community at Coondewanna Flats, BHP Billiton Iron Ore considers that the continued integrity and or viability of the community will not be significantly affected by direct impacts.

Indirect impacts to the Coolibah-lignum Flats PEC Subtype 1 (P3) and Subtype 2 (P1), occurring in Coondewanna Flats, from the Full Conceptual Development Scenario are expected to be most significantly associated with changes to ground and surface water regimes. Coondewanna Flats has been assessed as a key ecological receptor in the Ecohydrological Change Assessment (Appendix 7). Without management, Coondewanna Flats is expected to experience cumulative surface water reduction under the Full Conceptual Development Scenario. This is considered to be important as the area is an important zone of ground water recharge. The groundwater table is located between 20 and 30 m below the surface and may experience a moderate cumulative drawdown as a result of surrounding mining activity. This is unlikely to have an impact on surface communities as their ecological water requirements are considered to be predominantly met by surface water and associated soil moisture. Indirect impacts from groundwater and surface water change are discussed in Section 8.2. Surface and groundwater change at Coondewanna Flats will be managed using a regionally based groundwater management plan, by applying the Water Management Toolkit (Section 8.2.1.3) and potential impacts to the PEC's occurring within the area will be managed as a Tier 1 asset.

BHP Billiton Iron Ore considers that with the application of management as a Tier 1 Asset the potential impacts to this community from the Full Conceptual Development Scenario can be managed to an acceptable level. Furthermore, the Derived Proposal process allows opportunities to further reduce impact to this PEC during the detailed design and planning stage for the Mudlark hub. The mitigation hierarchy will also be applied using the Land and Biodiversity and Water Management toolkits (Figure 17 and Figure 42).

BHP Billiton Iron Ore's Full Conceptual Development Scenario footprint areas also overlap buffer areas of the following TECs and PECs:

- Fortescue Marsh (Marsh Land System);
- Weeli Wolli Spring Community; and
- Four Plant Assemblages of the Wona Land System.

Buffers are applied to TECs and PECs to ensure indirect impacts to the community are identified and managed and a precautionary approach is taken for those communities which have not been clearly mapped. Mining-related activities within TEC or PEC buffers have the potential to have indirect impacts upon that ecological community through such processes as groundwater drawdown, weeds, feral animals, and dust.

The cumulative Air Quality Assessment found that climate and meteorological characteristics of the Pilbara and its semi-arid landscape resulted in a naturally dusty environment. Vegetation that has evolved in this environment has a high degree of resilience to dust loading. The impacts of dust can be effectively managed using the mitigation hierarchy and are therefore not considered to be a significant indirect impact for these communities. Similarly indirect impacts associated with the introduction and spread of weeds beyond existing loads are considered to be low and manageable. Potential indirect impacts from the Strategic Proposal to these ecological communities are considered to be impacts from surface water and groundwater change. These impacts from BHP Billiton Iron Ore and reasonably foreseeable third-party iron ore operations are discussed in Section 8.2. Indirect impacts to TECs will receive the highest level of management to mitigate impacts to Tier 1 assets.

Impacts to Pilbara Biodiversity

Figure 21 shows the direct footprint associated with reasonably foreseeable third-party iron ore mines and BHP Billiton Iron Ore's 30% Conceptual Development Scenario and Full Conceptual Development Scenario. As shown in Figure 21, parts of BHP Billiton Iron Ore's Strategic Proposal tenure contain areas of predicted high biodiversity significance. These areas are discussed for each BHP Billiton Iron Ore tenement below, and mitigation of any potential impacts during implementation of the Strategic Proposal is described in Section 8.1.3.3:

- Upper Marillana/Munjina: The model indicates that part of Marillana Creek within this tenement is of predicted high biodiversity significance. This area is currently within the Full Conceptual Development Scenario footprint.
- Marillana: The southwestern edge of this tenement occurs on the edge of the Hamersley Range and is of predicted moderate biodiversity significance. This area is partly within the Full Conceptual Development Scenario footprint.
- Coondiner: Coondiner Creek runs through this tenement and is of predicted moderate biodiversity significance. The Full Conceptual Development Scenario overlaps with areas within and adjacent to Coondiner Creek.
- Jinidi:
  - The northern part of the tenement contains areas of predicted moderate to high biodiversity significance where Round Top Hill is located. The Full Conceptual Development Scenario does not overlap Round Top Hill.
  - Weeli Wolli Spring, which is a PEC (see Table 13), is located on the western boundary of the Jinidi tenement and is of predicted moderate to high biodiversity significance. The Full Conceptual Development Scenario overlaps the Weeli Wolli Spring Community buffer as discussed above. Indirect impacts to surface water and groundwater are discussed in Section 8.2.
- Gurinbiddy: Contains high peaks (predicted areas of high biodiversity significance) within the Hamersley Range that occur within the Full Conceptual Development Scenario footprint.
- Mudlark:
  - Coondewanna Flats is located within this tenement and contains the Coolibah–lignum Flats PEC described in Table 13. As described above, direct impacts from the Full Conceptual Development Scenario are expected to be approximately 2% of the PEC. Indirect impacts are described in Section 8.2.
  - This tenement also contains Mount Robinson, which is another area of high biodiversity significance. The Full Conceptual Development Scenario footprint does not overlap this area.
- Newman:

- Contains an area of predicted high biodiversity significance on the Fortescue River downstream of Ophthalmia Dam, coinciding within the Ethel Gorge Stygobiont Community TEC (see Table 13). The Full Conceptual Development Scenario footprint does not overlap the area of predicted high biodiversity significance.
- Shovellana Hill is of predicted moderate to high biodiversity significance, which the Full Conceptual Development Scenario partially overlaps.

BHP Billiton Iron Ore recognises that areas of modelled high biodiversity significance occur within parts of the Strategic Proposal tenure. In many cases, as described above, these areas occur within TECs or PECs and would be managed as key assets described in Section 6.2 using mitigation measures from the Land and Biodiversity Management toolkit (see Figure 17).

Areas that have been modelled as of high biodiversity significance but are not recognised as TECs or PECs will form part of the key environmental considerations for validation at the Derived Proposal stage, and would be managed accordingly. For example, areas of high biodiversity significance would be verified with baseline and targeted surveys, and any unique ecological communities identified would be considered to be Tier 2 assets and managed appropriately on a case-by-case basis. An example of this is Case Study 1 (see Section 8.1.3.3), where a calcrete community was identified within the Jinidi tenement, and although it was recognised as unique, it was not recognised as a TEC or PEC.

8.1.3 FLORA AND VEGETATION ASSESSMENT

8.1.3.1 EXISTING ENVIRONMENT

Vegetation Associations

Systematic flora surveys of the Pilbara region are limited to work completed by Burbidge (1959) and Beard (1975) and further refining of the Beard (1975) mapping by Shepherd et al. (2001). Beard (1975) divides the Pilbara region into three botanical provinces: the Northern, the Eremaean and the Fortescue.

Beard (1975) identified 89 broad vegetation associations (mapped at a 1:1,000,000 scale) within the Pilbara region, of which 41 occur within the Project Definition Boundary (Figure 22). The current extents of these broad vegetation associations are presented in the 2013 state-wide vegetation statistical dataset published by the Department of Parks and Wildlife (Government of Western Australia 2013).

According to the dataset (Government of Western Australia 2013), 87 of the vegetation associations mapped in the Pilbara region have retained more than 86% of their pre-European extent. One association (association 125 – bare areas, salt lakes) has less than 25% of its pre-European extent remaining. This association does not occur within the Project Definition Boundary.

In addition to this regional-scale mapping, BHP Billiton Iron Ore commissioned Onshore Environmental (Onshore 2014) to consolidate years of vegetation mapping commissioned by BHP Billiton Iron Ore into a single regional GIS dataset and report. The consolidated dataset provides methodological and nomenclatural consistency across BHP Billiton Iron Ore’s tenure and is updated on an ongoing basis as more surveys are completed. Supplementary field assessments were undertaken to address any gaps in baseline data or to verify the results from earlier surveys. The dataset includes mapping of vegetation associations and vegetation condition using the Keighery (1994) condition scale. The vegetation association mapping provides local-scale information that will be used as part of the Derived Proposal process and is shown in Figure 23a, b, c and d.

Vegetation association and condition is currently mapped over 422,425 ha of BHP Billiton Iron Ore tenure, with a combination of broad-scale and fine-scale mapping. Most of the remaining, unmapped vegetation is at the proposed BHP Billiton Iron Ore Roy Hill tenement and Ministers North tenement, and parts of Ophthalmia / Prairie Downs tenement and Newman mining hub in the central Pilbara. Vegetation associations that are unique or potentially restricted but are not formally recognised as TECs or PECs are considered to be Tier 3 assets (see Section 6.2).

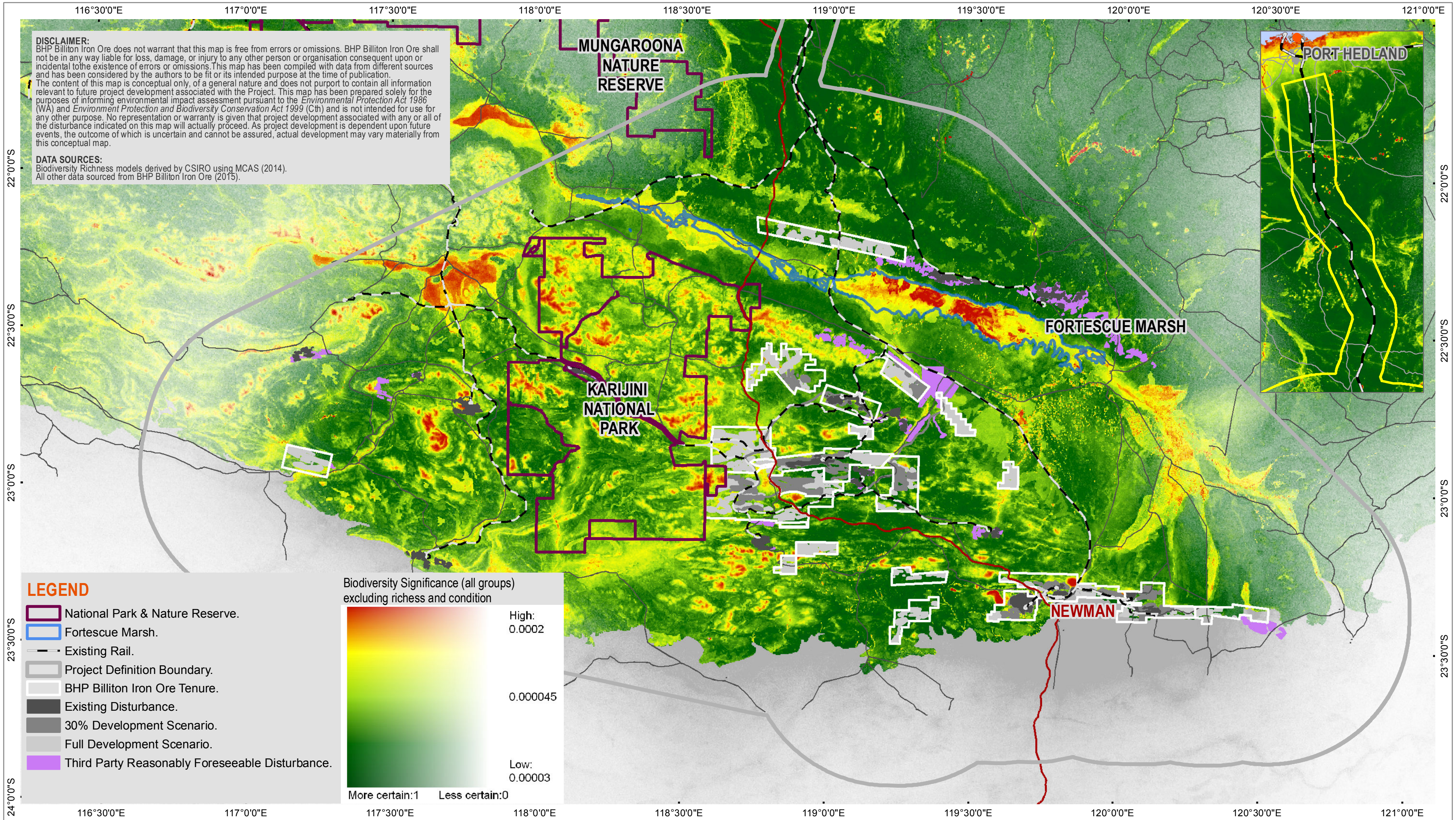

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Figure 21 Spatial prediction of biodiversity significance for the Pilbara bioregion relative to the development scenarios

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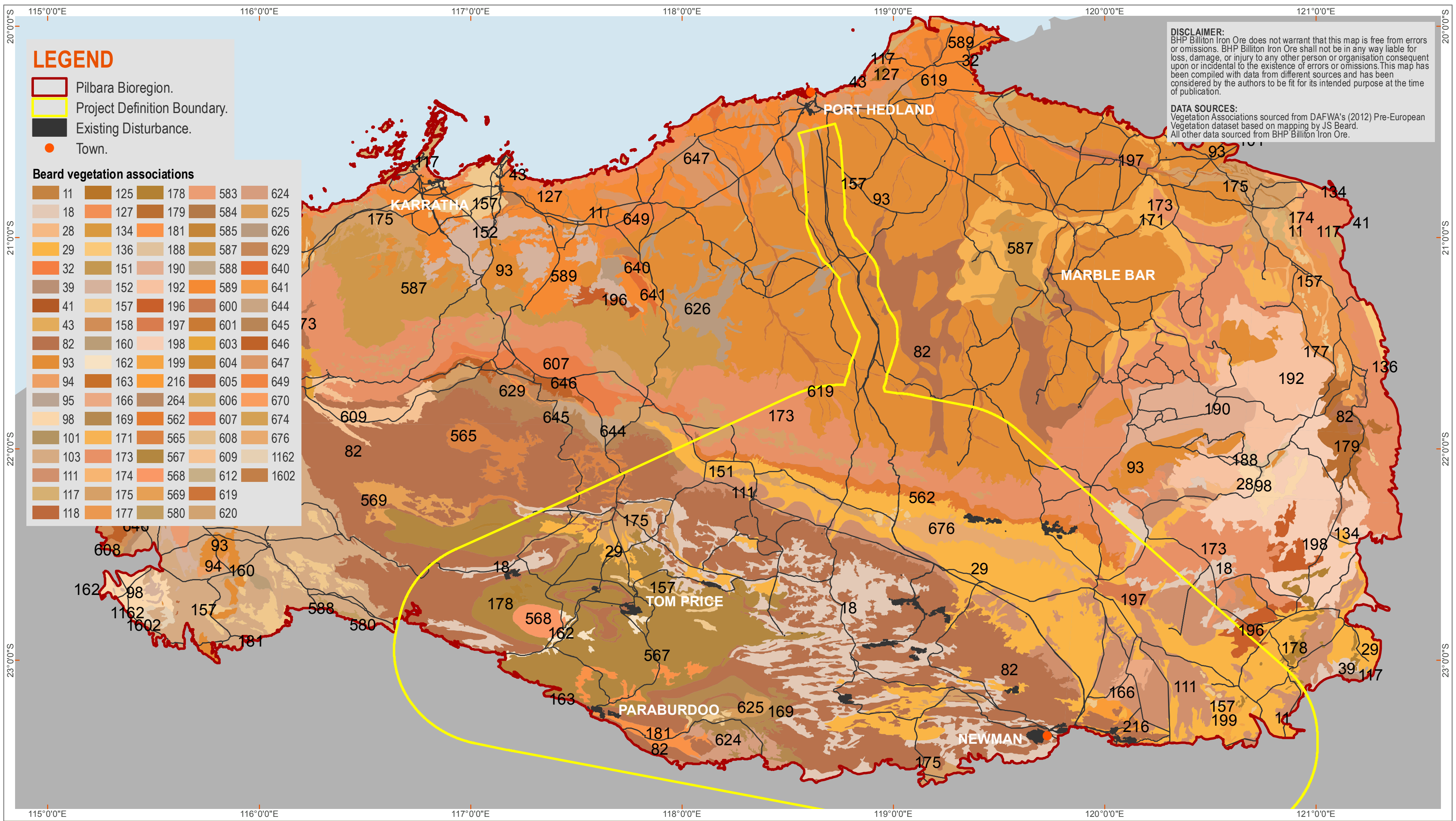

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Figure 22 Beard vegetation associations relative to the Project Definition Boundary

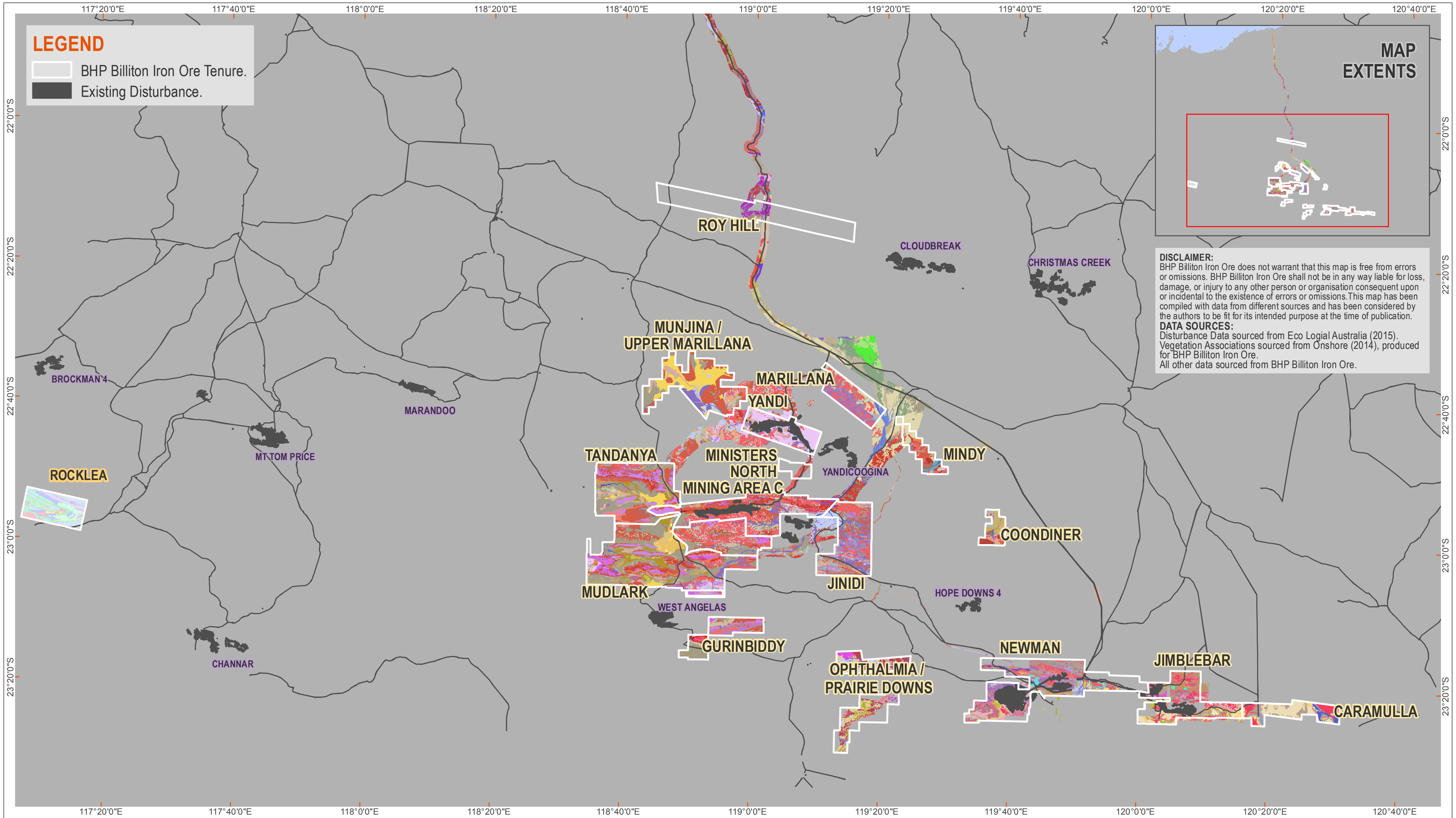

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Figure 23a Vegetation associations across BHP Billiton Iron Ore tenure (overview)

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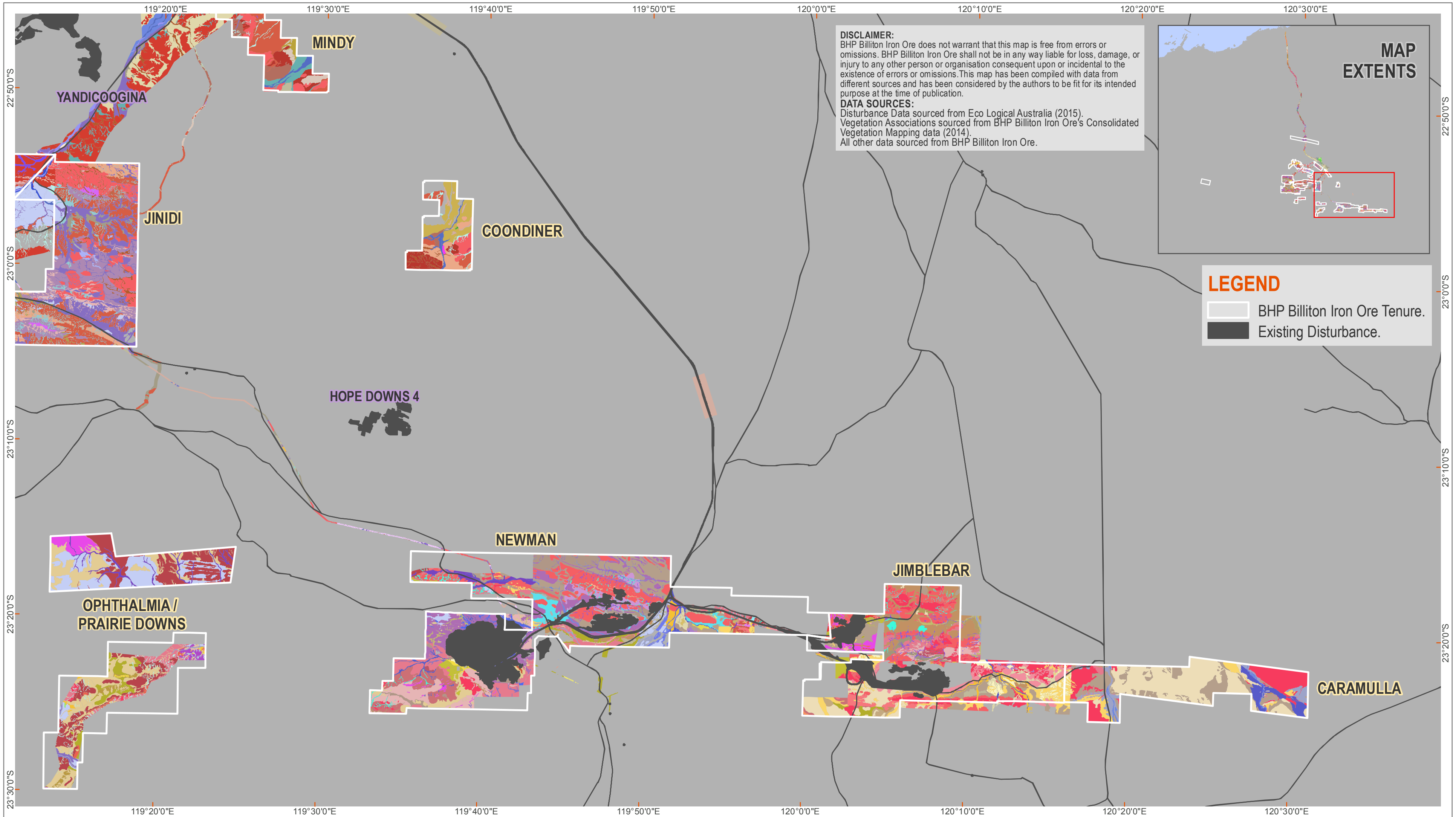

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Figure 23b Vegetation associations across BHP Billiton Iron Ore tenure (east)

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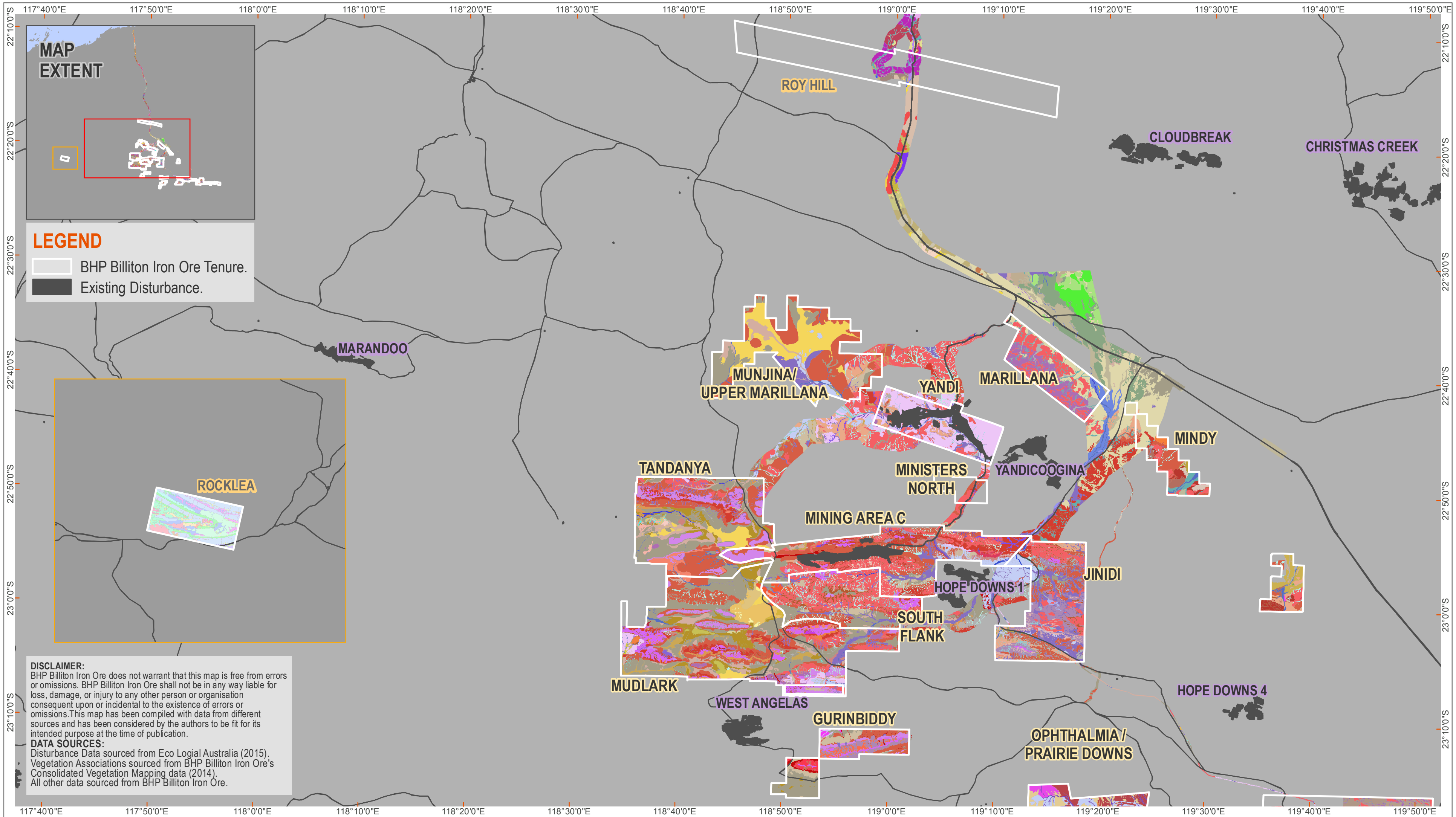

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Figure 23c Vegetation associations across BHP Billiton Iron Ore tenure (central)

STRATEGIC PROPOSAL

VEGETATION ASSOCIATIONS AND THEIR BROAD FLORISTIC DESCRIPTIONS

CALCRETE PLAINS
- **CP EinTlBe Apr Es** - Enneapogon Open Tussock Grassland
- **CP TlTe AbAstPfm** - Triodia Hummock Grassland
- **CP TwTa Es AbPlApy** - Triodia Hummock Grassland

FLOOD PLAINS
- **FP Aa CfCc PlaEla** - Acacia Low Closed Woodland
- **FP Aa Ch TtCfAco** - Acacia High Shrubland
- **FP AaAcaApa ElaSlPo AcoEdAj** - Acacia Low Open Woodland
- **FP AaAciApr AsyAscAb Tp** - Acacia Low Open Woodland
- **FP AaApaApt TtCfEb** - Acacia Low Open Forest
- **FP AaApr EcuClSp TpTw** - Acacia Low Open Forest
- **FP AaAprAca EffDpeSe AcoDamAin** - Acacia Low Woodland
- **FP AaAprAci ReAa CcCfAin** - Acacia Low Woodland
- **FP AaAprCh EfrAteDpe AinCfAco** - Acacia Low Open Woodland
- **FP AaAscAan Tp** - Acacia High Shrubland
- **FP AaCa Mv Tm** - Acacia Low Open Forest
- **FP AaEv EaEb Mf** - Acacia Open Forest
- **FP AaEv EbEa Mf** - Acacia Closed Forest
- **FP AaEv Mf EaEbAco** - Acacia Low Woodland
- **FP AayAaApt Tp Cc** - Acacia Low Open Forest
- **FP AbApr Tp AcoSau** - Acacia High Shrubland
- **FP AcaAaEx Eff Tp** - Acacia Low Woodland
- **FP AciAa Cc Bb** - Acacia Low Open Forest
- **FP AciChAa AanApyPl TtAinCc** - Acacia Low Woodland
- **FP AlaEseApe SfSh** - Aristida Open Tussock Grassland
- **FP ApaAa Efr TsTp** - Acacia High Open Shrubland
- **FP ApaAaApr AsyEffPo CcAinAco** - Acacia Low Woodland
- **FP Ast AtrHl TbTp** - Acacia Low Open Heath
- **FP AsuAaArh EcoEcaEff AcoEpo** - Acacia High Open Shrubland
- **FP Ax AsyRe MpMtScu** - Acacia Low Open Woodland
- **FP Cc ApyAsyApr** - *Cenchrus Tussock Grassland
- **FP Cc Sco** - *Cenchrus Scattered Tussock Grasses
- **FP CcCs ChAa AtpAan** - *Cenchrus Closed Tussock Grassland
- **FP CcaCa AtpAcc Tp** - Corymbia Low Woodland
- **FP CfEaEo ChCca GwCci** - Chrysopogon Open Tussock Grassland
- **FP EaEbTt EvAa Mf** - Eulalia Tussock Grassland
- **FP EbEa Hl Acc** - Eriachne Tussock Grassland
- **FP EbEaTt Ev Mf** - Eriachne Tussock Grassland
- **FP EcuFsRe AsyMtSas Aa** - Eremophila Low Open Shrubland
- **FP Ev Aa EaEbTt** - Acacia Low Woodland
- **FP Mosaic mulga snakewood** - Mosaic: Acacia Low Open Woodland/ Acacia Low Woodland
- **FP Mosaic snakewood angusta** - Mosaic: Acacia Low Open Woodland/ Triodia Closed Hummock Grassland
- **FP MtPoSc AxAsy AinCc** - Maireana Low Open Shrubland
- **FP PfmPrCl Ta SauCpePd** - Pluchea Low Shrubland
- **FP Tb AaApr Eff** - Triodia Hummock Grassland
- **FP TbTp AaGb Go** - Triodia Hummock Grassland
- **FP Ths Ca PoSau** - Themeda Closed Tussock Grassland
- **FP TlTp AscAbMg** - Triodia Closed Hummock Grassland
- **FP Tp ChApr GwApyAb** - Triodia Hummock Grassland
- **FP Tp EtEg AbAanPl** - Triodia Hummock Grassland
- **FP Ts Eg AayAaAca** - Triodia Hummock Grassland
- **FP TsTl AbAsPfm** - Triodia Hummock Grassland
- **FP TscTp ExAaApr AteAscGw** - Triodia Open Hummock Grassland
- **FP TtEa ExAa AprAtpElo** - Themeda Tussock Grassland
- **FP TtEaCc ChEx AdAaAmc** - Themeda Tussock Grassland
- **SP TpTb Eg PlAbAan** - Triodia Hummock Grassland

FOOTSLOPES
- **FS Ts CdHc AanAiGw** - Triodia Hummock Grassland
- **FS TsTpTw El AbApaAan** - Triodia Hummock Grassland
- **FS Tw El** - Triodia Hummock Grassland
- **SP TpTb Eg PlAbAan** - Triodia Hummock Grassland

GILGAI PLAINS
- **GP Asy AsySaoEla CcCsCf** - Acacia High Open Shrubland
- **GP CcCs AaApr AsyAa** - *Cenchrus Open Tussock Grassland
- **GP EbEf Aa Asy** - Eriachne Tussock Grassland
- **GP ExeEbCf AsyAteVf NdTc** - Eragrostis Tussock Grassland
- **GP SfScoGpr** - Sida Very Open Herbs

GORGES AND GULLIES
- **GG AaAcaEl DpaEtEj TpTw** - Acacia Low Woodland
- **GG AadAca AmuAaAte Tp** - Acacia Low Open Forest
- **GG CcoCfeEl EmuTmbCa** - Callitris Low Open Forest
- **GG CfeElFb AhDvmAha CaEmuTmb** - Corymbia Low Woodland
- **GG Tp CfeFbAca DpaAh** - Triodia Open Hummock Grassland
- **GG Tp ElCfe Dpa** - Triodia Hummock Grassland
- **GG TtEmuTmb ElChCfe AtpGrPl** - Themeda Tussock Grassland

GRANITE OUTCROPS AND ROCK PILES
- **GR Atp Te TloAcoSau** - Acacia High Open Shrubland
- **GR Te AdTmaCci PclCc** - Triodia Open Hummock Grassland

HILL CRESTS AND UPPER HILL SLOPES
- **HC TbTp El AatAmmAma** - Triodia Open Hummock Grassland
- **HC TbTp ElCh AmoApy** - Triodia Open Hummock Grassland
- **HC Tbr AiAmm** - Triodia Closed Hummock Grassland
- **HC Te AdCc Gw** - Triodia Hummock Grassland
- **HC Te AiAanAarr** - Triodia Hummock Grassland
- **HC TeTl ArAiAb** - Triodia Hummock Grassland
- **HC Tp AaAprAca EllEfrEex** - Triodia Open Hummock Grassland
- **HC TpTs El AaAkAsi** - Triodia Hummock Grassland
- **HC TpTw El NhrOs** - Triodia Closed Hummock Grassland
- **HC TpTwTs ElCh AarGoKv** - Triodia Hummock Grassland
- **HC TsTp EkEg** - Triodia Hummock Grassland
- **HC TsTp ElAa PcGs** - Triodia Open Hummock Grassland
- **HC Tw Ah EkEgCh** - Triodia Hummock Grassland
- **HC Tw AiAb IrSao** - Triodia Hummock Grassland
- **HC TwTbrTp ElCh AmaGwAb** - Triodia Hummock Grassland
- **HC TwTsTp ElCh Ah** - Triodia Hummock Grassland

HILL SLOPES AND LOW UNDULATING HILLS
- **HS AaAh Sgl TaTp** - Acacia High Shrubland
- **HS AaApr EjAmmCco TwTp** - Acacia Low Woodland
- **HS AaAteApr TaTp Ab** - Acacia High Shrubland
- **HS AbAsy TseTaTb** - Acacia Low Open Heath
- **HS AcaAaApr SaEllAb TbrTw** - Acacia Low Open Forest
- **HS Aci Efr Tw** - Acacia High Open Shrubland
- **HS ArhEex Apr TsTw** - Acacia Open Shrubland
- **HS EliCa EfrAte ImDau** - Enneapogon Tussock Grassland
- **HS Mosaic hill crests and slopes** - Mosaic: Triodia Open Hummock Grassland/ Triodia Hummock Grassland
- **HS Mosaic low granite hills** - Mosaic: Triodia Hummock Grassland / Acacia High Open Shrubland
- **HS Tb El AbAiPl** - Triodia Hummock Grassland
- **HS Tb** - Triodia Hummock Grassland
- **HS TbTeTw AtpGw AanAbAac** - Triodia Hummock Grassland
- **HS TbTs AsyAaAte EcuMgSl** - Triodia Open Hummock Grassland
- **HS Tbr El Er** - Triodia Hummock Grassland
- **HS TbrTeTw Ch Aac** - Triodia Hummock Grassland
- **HS TbrTw AiAprHc EfrEpl** - Triodia Hummock Grassland
- **HS TbrTw El AbPoSgg** - Triodia Hummock Grassland
- **HS TeTbTw AorAi** - Triodia Hummock Grassland
- **HS TeTw Ch AiAan** - Triodia Hummock Grassland
- **HS TlTwTe AtpAerAcc AiAor** - Triodia Hummock Grassland
- **HS TmTp ElCh MvSarKv** - Triodia Hummock Grassland
- **HS TmeTp AprAcaAmu CaEmu** - Triodia Open Hummock Grassland
- **HS Tp AaApr EfrAmmSgl** - Triodia Open Hummock Grassland
- **HS Tp AaGb AanAbAa** - Triodia Hummock Grassland
- **HS Tp Ama Tt** - Triodia Hummock Grassland
- **HS Tp El SggGwEll** - Triodia Open Hummock Grassland
- **HS Tp Ir Gp** - Triodia Hummock Grassland
- **HS TpTb ElAaAca SsSglEcu** - Triodia Open Hummock Grassland
- **HS TpTb ElCh EmuElAh** - Triodia Hummock Grassland
- **HS TpTbTe Ch Ai** - Triodia Hummock Grassland
- **HS TpTs CdEl AanAbAte** - Triodia Hummock Grassland
- **HS Ts** - Triodia Hummock Grassland
- **HS TsTbrTb ElAa Ab** - Triodia Hummock Grassland
- **HS TsTp AaAprAci AaEllSgl** - Triodia Hummock Grassland
- **HS TsTpTb AaAprAw AteEexEll** - Triodia Open Hummock Grassland
- **HS TsTw Eg GwSggAb** - Triodia Hummock Grassland
- **HS TsTwTp ElCh AhiAad** - Triodia Hummock Grassland
- **HS Tw Cd AarAsiAb ArhAprAa** - Triodia Hummock Grassland
- **HS Tw ElChHc AanAbAa** - Triodia Hummock Grassland
- **HS TwTbrTs ElExCh PcaPasAhl** - Triodia Hummock Grassland
- **HS TwTpTbr El Ep** - Triodia Hummock Grassland
- **HS TwTpTs El AprAaAan** - Triodia Hummock Grassland
- **HS TwTs HcAbGw AptAhi** - Triodia Hummock Grassland

MAJOR DRAINAGE LINES
- **MA AaAciApr CcTtCf EvEc** - Acacia Low Open Forest
- **MA AciAprAa SahSgl** - Acacia Low Closed Woodland
- **MA AtpApyAse Ec TmbTtCpr** - Acacia High Shrubland
- **MA Cc** - *Cenchrus Tussock Grassland
- **MA CcCs EvAciAh** - *Cenchrus Tussock Grassland
- **MA CcTtEa ChCa AbAtpAsc** - *Cenchrus Tussock Grassland
- **MA ChEv ApyCci Cf** - Corymbia Low Woodland
- **MA EcEv AciApyMg CcEaTt** - Eucalyptus Woodland
- **MA EcEvEx ApyAtpGr TtEaCpr** - Eucalyptus Low Open Forest
- **MA EcEvMa AcpAamAh TdCv** - Eucalyptus Open Forest
- **MA EcMaEv AciAcp AbGsGr** - Eucalyptus Open Forest
- **MA EvAciEc TrcCcrApy CcEaTt** - Eucalyptus Woodland
- **MA MaEc AciAcpAam TdCv** - Melaleuca Open Forest
- **MA MaEcEv MgAcpAtr Cv** - Melaleuca High Open Forest
- **MA TdCv EcEv AciAcp** - Typha Sedges
- **MA TtCc PlAbAlu ElCh** - Themeda Tussock Grassland

MEDIUM DRAINAGE LINES
- **ME AamAtrAcp CcEb Cv** - Acacia High Shrubland
- **ME AtpAanAcc TeTl Ch** - Acacia Open Scrub
- **ME EbEf Ev Te** - Eriachne Tussock Grassland
- **ME Ev PrPfmAbu Ecu** - Eucalyptus Low Open Woodland
- **ME EvAcp AtpAtrApy Tp** - Eucalyptus Low Woodland
- **ME Gl Ev Sn** - Glinus Herbs
- **ME TpTb Ch AtpAcc** - Triodia Hummock Grassland
- **ME TpTl ExAciCh PlApyGr** - Triodia Hummock Grassland
- **ME TscTs Ch AadEloAan** - Triodia Open Hummock Grassland
- **ME Tt ExChAa ApaAaAci** - Themeda Closed Tussock Grassland
- **ME TtAinCa ChEl AmoPlAlu** - Themeda Open Tussock Grassland
- **ME TtCfEa ExEvCh PlApaApy** - Themeda Tussock Grassland
- **ME TtEaEte ApyAtpPl EvCh** - Eucalyptus Low Woodland

MINOR DRAINAGE LINES
- **MI AadAluDpa Tp ElCh** - Acacia Open Heath
- **MI AbAdAma Tp TtPmEa** - Acacia Shrubland
- **MI AccAbAtp TlTe AstPfmPt** - Acacia High Shrubland
- **MI AmoAanPl ChEl TtAin** - Acacia Shrubland
- **MI AtpGwApy TpTb CcCs** - Acacia Open Scrub
- **MI AtpPlAmo TpTs ChEl** - Acacia Open Scrub
- **MI CcAa CcCs Tb** - Corymbia Low Open Woodland
- **MI EaTt AxAcp AanAtp** - Eulalia Open Tussock Grassland
- **MI Eb VfAteAa PhCmPg** - Eriachne Tussock Grassland
- **MI EbEfCf Ca AtrAcc** - Eriachne Open Tussock Grassland
- **MI PlAtpAmo ChEl TwTp** - Petalostylis Shrubland
- **MI TeTb Ch CciApy** - Triodia Open Hummock Grassland
- **MI TlTe Ch AtrAanAac** - Triodia Hummock Grassland
- **MI TsTp AanAmoGw** - Triodia Hummock Grassland
- **MI TtCobEmu ChEg GwPlEt** - Themeda Tussock Grassland

SALINE FLATS AND MARSH
- **SF Fs Cc** - Frankenia Low Open Shrubland
- **SF TdcTibMf Ep** - Tecticornia Low Open Heath

SAND DUNES
- **SD TscTb Ad CtCcuSc** - Triodia Hummock Grassland

SAND PLAINS
- **SA AChAprGs GstApaAan TbTsc** - Corymbia Low Open Woodland
- **SA Aa TpTwTb CcCf** - Acacia Low Open Forest
- **SA Ast Tsc AtpAccMl** - Acacia Low Open Heath
- **SA Mosaic granitic plains** - Mosaic: Triodia Hummock Grassland/ Acacia High Open Shrubland
- **SA Mosaic sand plains** - Mosaic: Triodia Hummock Grassland
- **SA SahCpEla HlAmc AcoPclEar** - Senna Low Open Shrubland
- **SA Tb AaApr Aan** - Triodia Hummock Grassland
- **SA Tb ChEg SpBeKp** - Triodia Hummock Grassland
- **SA TbTl AsyAscElo Aa** - Triodia Closed Hummock Grassland
- **SA TeTl Ai Aco** - Triodia Hummock Grassland
- **SA Tl AanApa ApaAprCh** - Triodia Open Hummock Grassland
- **SA Tl AiAan Ast** - Triodia Hummock Grassland
- **SA Tl CzCh Ai IalmTbc** - Triodia Open Hummock Grassland
- **SA Tp Ev AccAst** - Triodia Hummock Grassland
- **SA Tsc HlApaAd ScDcSp** - Triodia Hummock Grassland

STONY PLAINS
- **SP Aa EfrSgl TtAco** - Acacia Low Woodland
- **SP AaAanApr TeTs EffGbDpe** - Acacia Low Open Forest
- **SP AaApr TmTwTp TtCfAin** - Acacia Low Open Forest
- **SP AaAprAx Eff Tp** - Acacia Low Open Woodland
- **SP AcaAa AobDamCf** - Acacia Low Open Forest
- **SP ApeAinSau SfiCtrTbc Oa** - Astrebla Tussock Grassland
- **SP AprAa AiAb Ts** - Acacia Low Woodland
- **SP AsyAxAa AbuMp CcCsCf** - Acacia Open Scrub
- **SP Ax SggSbSg ApeEobEx** - Acacia Low Open Forest
- **SP AxAa EffAteAsy CfAcoSau** - Acacia Low Open Forest
- **SP CcAbu AaAbGs MgMmPn** - *Cenchrus Open Tussock Grassland
- **SP ChEoCd AanApaAad TbTscTs** - Corymbia Low Open Woodland
- **SP DrhThiPae** - Dysphania Herbs
- **SP Mosaic granite / calcrete** - Mosaic: Triodia Hummock Grassland/ Acacia High Open Shrubland
- **SP Tb AaApr AwAanAi** - Triodia Hummock Grassland
- **SP Tb AbAprAad** - Triodia Hummock Grassland
- **SP TbTp HlAanAi Ch** - Triodia Hummock Grassland
- **SP TlTe Ai AanAb** - Triodia Hummock Grassland
- **SP TpTb AccAi AccAan** - Triodia Hummock Grassland
- **SP TpTb Eg PlAbAan** - Triodia Hummock Grassland
- **SP TpTm AaExAca ApaEffAad** - Triodia Open Hummock Grassland
- **SP TpTwTs EfrSgpSao** - Triodia Hummock Grassland
- **SP Ts Ai** - Triodia Hummock Grassland
- **SP TsTwTp EgEt AbApaApr** - Triodia Hummock Grassland

Figure 23d: Vegetation associations across BHP Billiton Iron Ore tenure - legend

Vegetation Condition

Pilbara landscapes have been modified by pastoral use, mining activities and altered fire regimes for more than a century (DPaW 2014). The most frequently observed impact of pastoralism in the Pilbara is the loss of perennial species richness and perennial plant diversity. Vegetation types that are preferentially grazed are often associated with soils that are susceptible to erosion (van Vreeswyk et al. 2004), with areas with low pastoral value, such as the rugged upland areas, showing fewer disturbances (DPaW 2014). These findings are consistent with Onshore's (2014) assessment of vegetation across BHP Billiton Iron Ore tenements (Figure 24a, b and c). Onshore (2014) identified that vegetation of lower condition generally occurred in areas of lower relief within such habitats as ephemeral drainage lines, flood plains, stony plains and gilgai plains. Vegetation of higher condition was generally found to occur within BHP Billiton Iron Ore's eastern and central Pilbara tenure (broadly south of the Marillana lease), as well as in the narrow upper gorge habitats of the southern tenure.

Pastoral impacts in areas of lower relief have contributed to the most noticeable reduction in vegetation condition. Direct impacts have been related to grazing by domestic cattle and feral herbivores and include reduction in native plant species richness, trampling of ground vegetation, pugging of surface soils, and introduction of weed species. Vegetation condition was always severely impacted around stock watering points. Wildfire is another major factor influencing vegetation structure and composition, with high fire intensity and short fire interval both being negative factors.

Conservation-significant Flora

Flora data provided by DPaW in December 2015 and internal BHP Billiton Iron Ore data identified 128 conservation-significant flora species (those listed under the state WC Act or the EPBC Act or listed as Priority species by DPaW) within the Project Definition Boundary. There were two Threatened species, 39 Priority 1 species, 19 Priority 2 species, 58 Priority 3 species, and 10 Priority 4 species. The full list is provided in Appendix 4.

The locations of conservation-significant flora are shown in Figure 25 by conservation status.

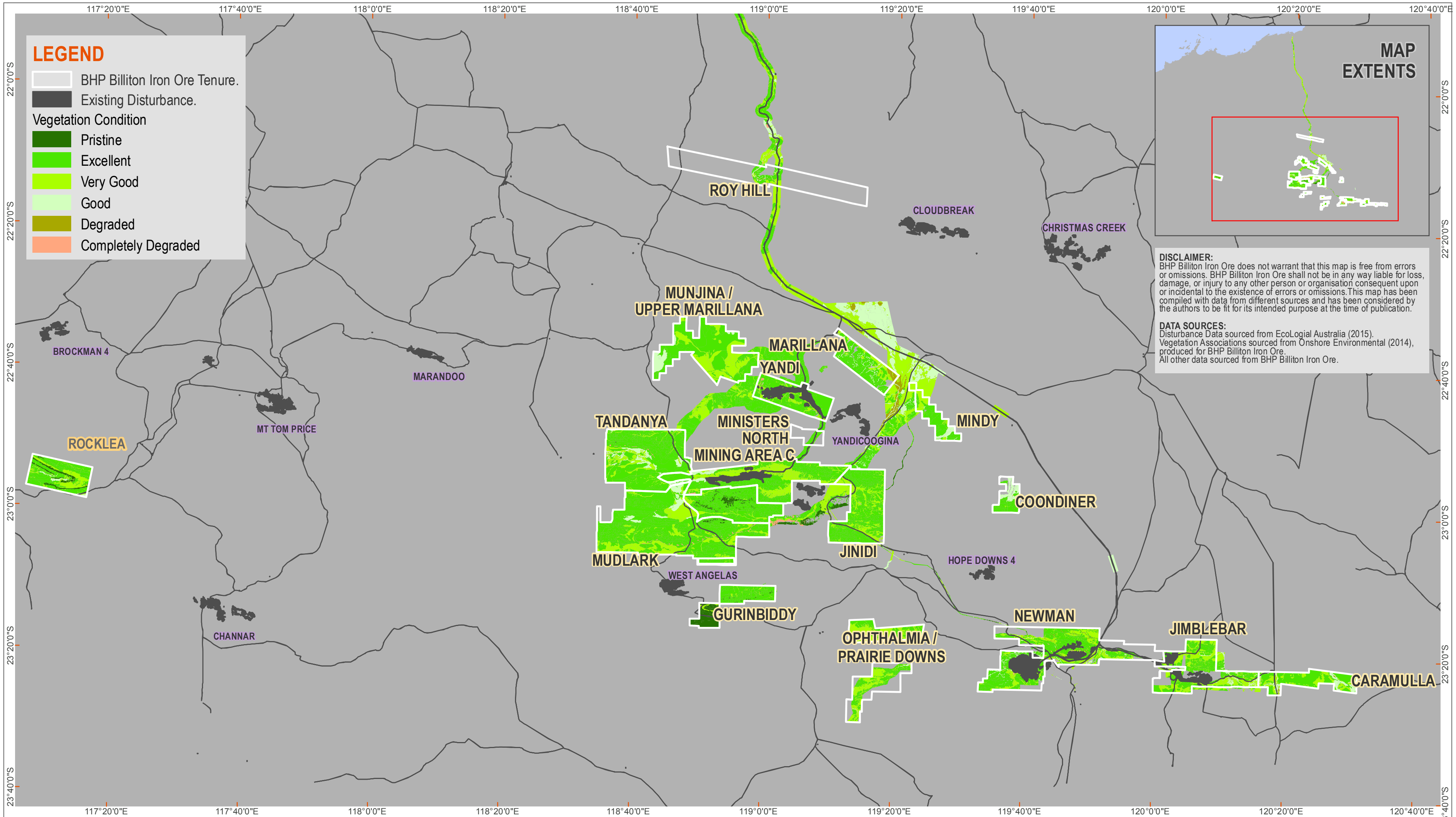

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Figure 24a Vegetation condition across Strategic Proposal tenure (overview)

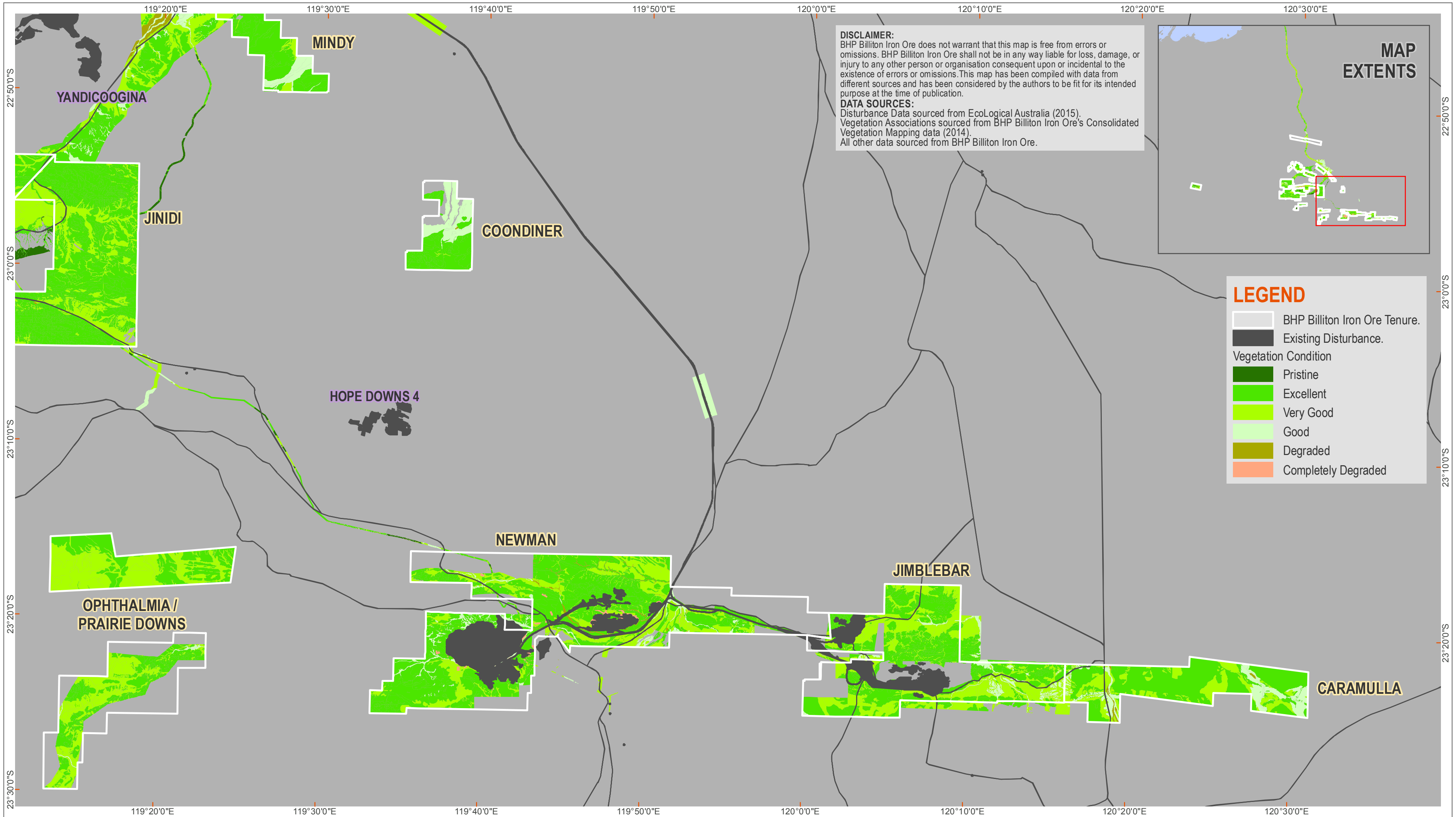

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Figure 20b Vegetation condition across Strategic Proposal tenure (east)

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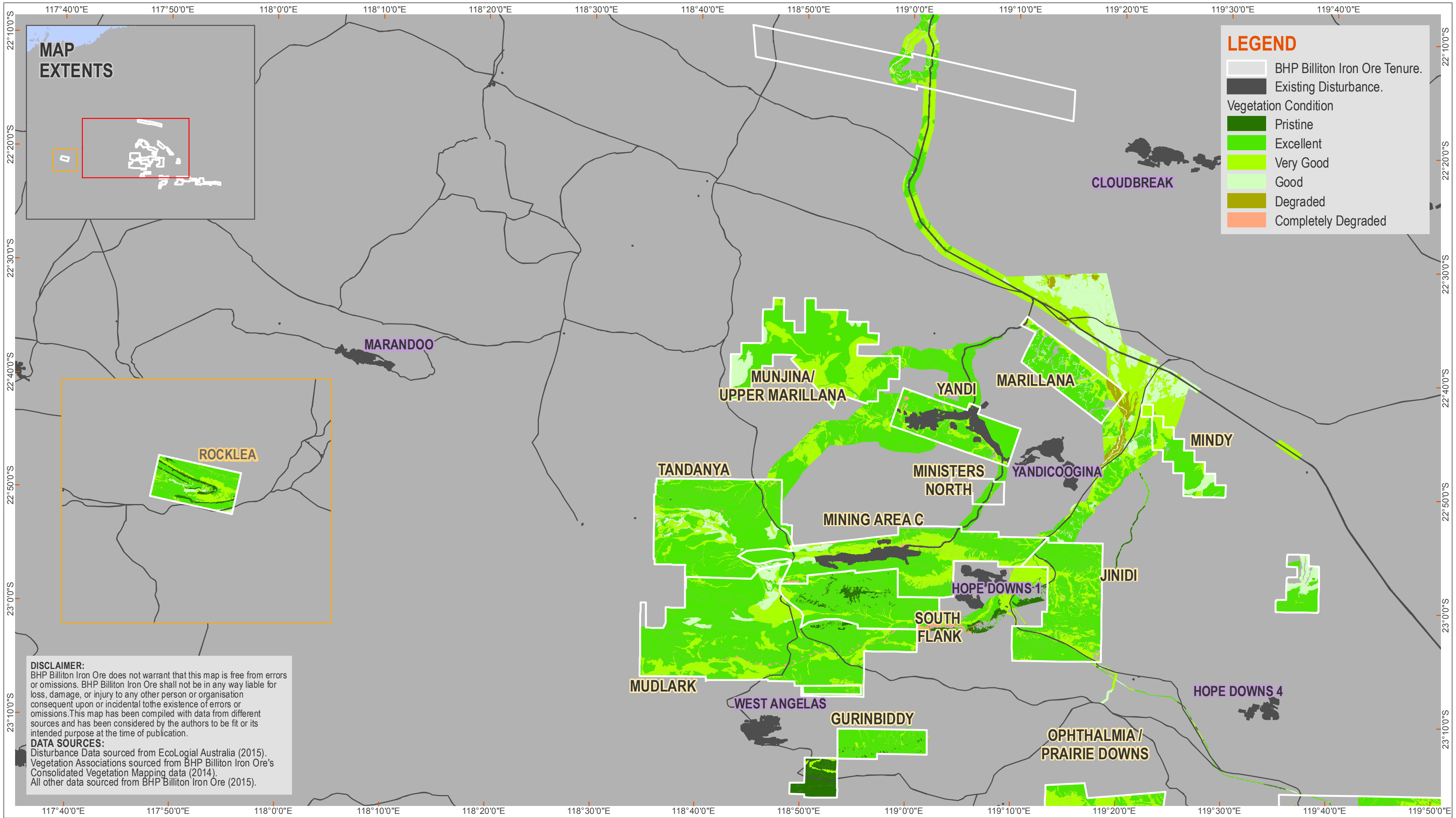

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Figure 24c Vegetation condition across Strategic Proposal tenure (central)

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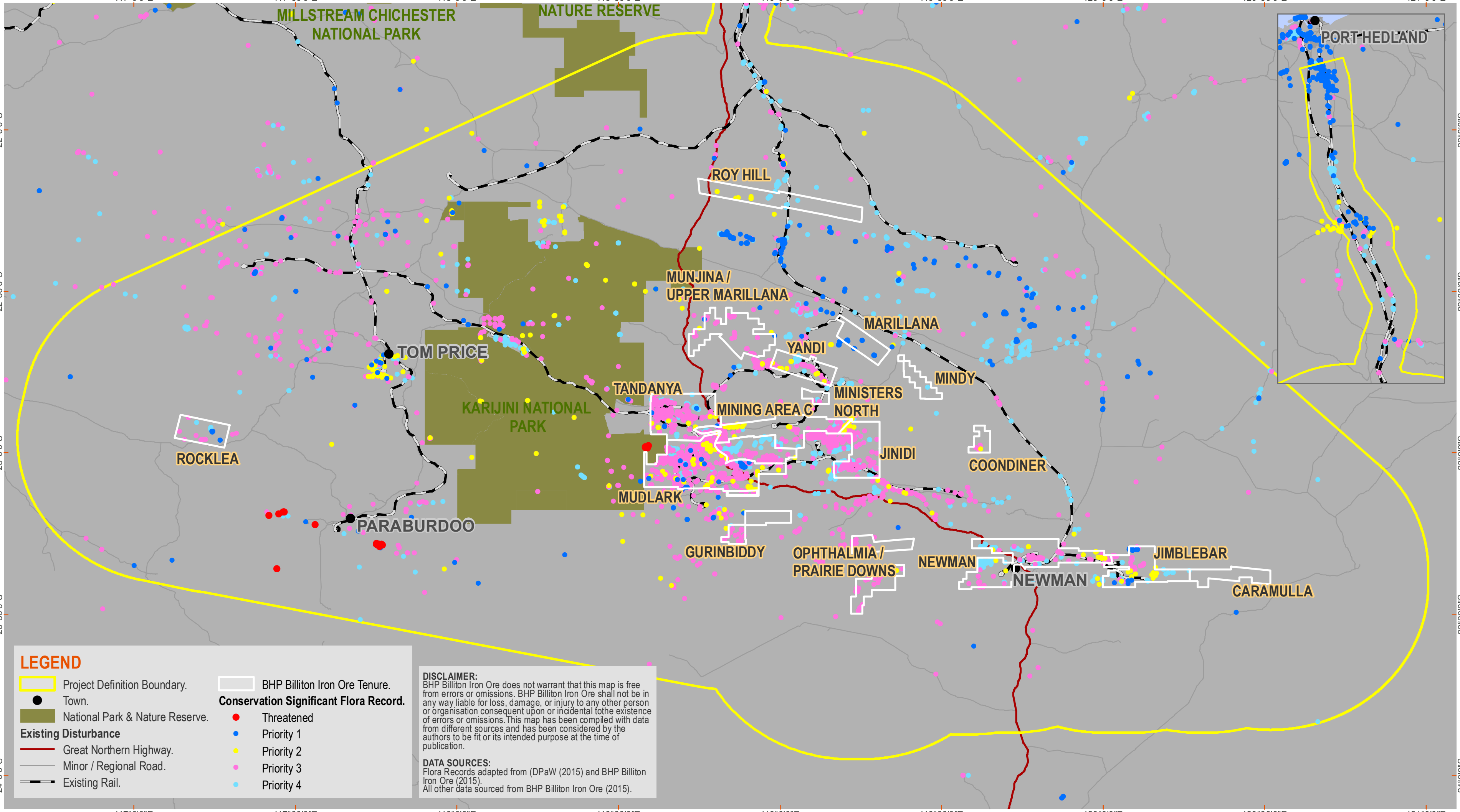

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Figure 25 Conservation-significant flora records relative to the Project Definition Boundary

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8.1.3.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara that are relevant to flora and vegetation and the potential impacts to biodiversity linked to these activities are listed in Table 15. A brief description of each potential impact is provided.

Table 15: Potential threats to flora and vegetation from mining activities

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Removal of Vegetation (direct)	Mining operations directly impact on flora and vegetation communities through the clearing of vegetation. This may include, but is not limited to, clearing for overburden storage areas, pits, transport, laydown areas and work areas. The extent of the clearing depends on a number of factors, such as the size of the development footprint, the vegetation cover within the footprint, and the mining and waste disposal methods used (e.g. backfilling versus out-of-pit waste storage). The significance of the environmental impact associated with vegetation clearing depends on such factors as the extent of clearing undertaken, the rarity and ecological function of the vegetation cleared, and the extent and viability of rehabilitation undertaken. The impact from removal of vegetation is assessed in Section 8.1.3.4.
Altered Water Regimes (indirect)	Groundwater is often abstracted to allow mining of deposits that occur below the groundwater table. Some of this water can be used during the mining process, while excess water is typically managed by reinjection, surface water discharge, and holding ponds and dams. Groundwater drawdown has the potential to impact upon groundwater-dependent vegetation .These activities may impact wetland flora and creek integrity. The discharge of water to ephemeral streams for extended periods and in an arid climate can alter the composition of ecological communities associated with these systems and can create an unnatural dependency on the water being discharged. The quality of water discharged to the environment has the potential to impact directly on species or communities. The discharging of water to surface and through managed aquifer recharge (MAR) has the potential to waterlog soils and directly impact individual plants and communities. Artificial water bodies (e.g. pit lakes, tailings dams, turkey's nests) can have both a positive and a negative impact on flora. Increasing the availability of water in an arid climate can promote weed growth and encourage weed competition with naturally occurring species and communities. In some areas, creeks may be realigned to avoid mineral deposits, or excess mine water may be pumped into or out of creeks. Alterations to landforms can lead to increased erosion and deposition of sediments in waterways. Changes to surface water flows (such as bunding or redirecting creeks) can impact downstream vegetation (particularly mulga) via shadow effects. Potential impacts of hydrological change are discussed in Section 8.2.
Fire (indirect)	Native flora and vegetation in the Pilbara is adapted to natural fire regimes. Mining activities have the potential to change the frequency of fire by actively extinguishing fires or by causing them. This may result in fire in certain parts of the landscape being too frequent or in other parts being not frequent enough and significantly intensified when it does occur. Changed fire regimes can encourage weeds at a landscape level and also alter the ecological characteristics of communities through the dominance of early successional species. The impact of fire is discussed in Section 8.1.3.4.
Weeds (indirect)	Mining activities have the potential to introduce and spread invasive weed species by transporting contaminated soil and seeds, either directly or contained within soil on machinery or via changed surface water regimes, which can move weeds to downstream areas. Weeds can potentially alter the characteristics of vegetation communities, including PECs and TECs, by outcompeting individual species, changing fire patterns and increasing erosion. Weeds can also compete with conservation-significant species for environmental resources. The impacts of weeds are assessed in Section 8.1.3.4, using distance to roads as an indicator for a negative impact to vegetation condition.

8.1.3.3 MITIGATION

BHP Billiton Iron Ore will apply mitigation measures from the Land and Biodiversity Management toolkit (Figure 17) to manage impacts to flora and vegetation. A summary of management actions routinely used by BHP Billiton Iron Ore to mitigate the threatening processes identified in Section 8.1.3.2 is provided in Table 16. Specific examples of the mitigation toolkit being implemented in existing and proposed operations are provided below.

Table 16: Potential management approaches for flora and vegetation

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Removal of Vegetation (direct)	• *Avoidance or minimisation through informed design* by avoiding or minimising clearing habitat for conservation significant species, through undertaking *baseline and targeted surveys* and where practicable altering mine plans to avoid significant habitats. • Avoid unauthorised clearing through *demarcation of clearing areas* and implementation of the *spatial on-site disturbance compliance tool* (i.e. PEAHR procedure; see Project Environment and Aboriginal Heritage Review in Section 8.1.3.3, Mitigation). • Apply the *Rehabilitation and Decommissioning Management toolkit* as required to cleared areas, progressively where possible, using provenance species. • Implement *regional state offset initiative* or *project-specific initiatives* where required to achieve the flora and vegetation objective, and undertake *offset monitoring* to ensure effectiveness.
Altered Water Regimes (indirect)	• Undertake appropriate *groundwater and surface management* to avoid significant impacts to areas with significant flora and vegetation or ecological value (refer to Section 8.2.2.3, Mitigation, in Section 8.2.2, Hydrological Processes and Inland Waters Environmental Quality). • Undertake *ecological asset monitoring* where appropriate for areas with significant flora and vegetation or ecological value. • Draft and implement *management plans* for key assets and significant species as described in Section 6.2. • Establish *performance criteria* to maintain significant flora and vegetation or areas with ecological value.
Fire (indirect)	Implement the *fire response procedure* to ensure that fire risk is managed to an acceptable level..
Weeds (indirect)	Undertake *weed control* to ensure that the Strategic Proposal does not encourage or exacerbate the spread or presence of weeds.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

Baseline and Targeted Surveys

BHP Billiton Iron Ore routinely undertakes baseline and targeted surveys across its tenure and the Pilbara region to understand the environment in which it operates. In August 2011, the Jinidi Iron Ore Mine was referred to the EPA under s. 38 of the EP Act. The project has since been withdrawn from a separate assessment and included within the scope of the Strategic Proposal and provides a useful example of the types of surveys that would be typically undertaken for a Derived Proposal (Case Study 1).

Case Study 1: Jinidi baseline flora and vegetation surveys and use at the Derived Proposal stage

Flora and vegetation surveys across BHP Billiton Iron Ore's sites generally use desktop analysis and systematic and opportunistic sampling, as well as targeted searches for conservation-significant flora, to determine the baseline characteristics of a project area. These methods are in line with the Western Australian EPA's Guidance Statement No. 51 (EPA 2004a), as well as other relevant EPA position statements, and are generally in line with the recently released Technical Guide - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA & DPaW 2015).

Source: BHP Billiton Iron Ore.
Plate: *Goodenia nuda*

At least eight flora and vegetation (and supporting) surveys have been undertaken since 2005 (together with an earlier survey in 1984) specifically within the proposed Jinidi project area, while at least nine other regional surveys have also been reviewed for contextual information.

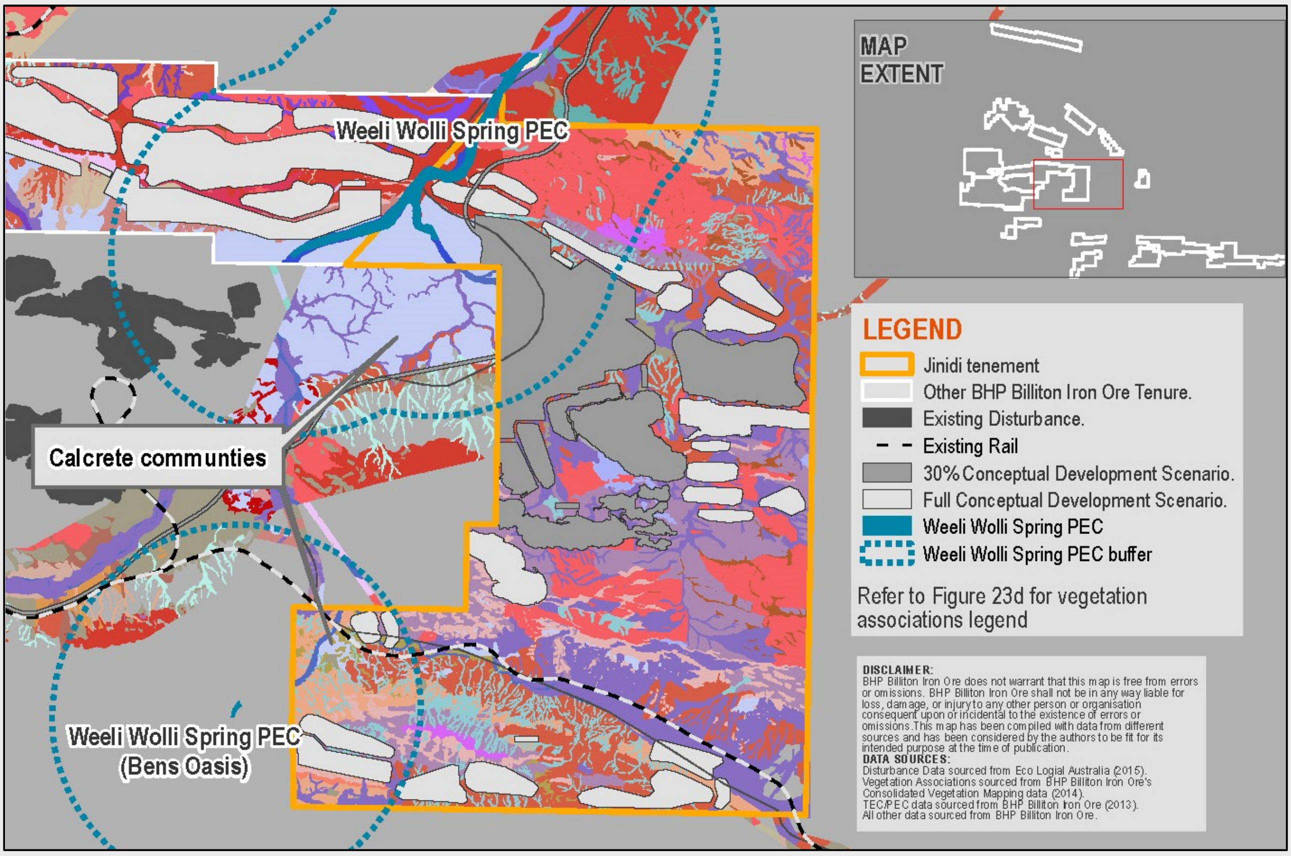
The results from the various flora and vegetation surveys undertaken have indicated that four Priority flora occur in the proposed Jinidi clearing footprint area.

These species are *Goodenia nuda* (Priority 4; pictured), *Indigofera gilesii* (Priority 3), *Goodenia* sp. East Pilbara (Priority 3), and *Acacia subtiliformis* (Priority 3). While the Commonwealth-listed Hamersley lepidium (*Lepidium catapycnon*) (Priority 4) is known from the area, it has not been identified to date within the development footprint.

The Weeli Wolli Spring PEC is located approximately 1.8 km northwest of the proposed Jinidi footprint. An expanse of outcropping calcrete south of Weeli Wolli Spring has been identified during surveys as a unique feature in the surrounding landscape that is known to support restricted vegetation (see map below).

Information gathered to support the Jinidi impact assessment has been collated along with data from other BHP Billiton Iron Ore tenure and available public data to provide a flora and vegetation dataset and regional map, part of which is shown below. The consolidated flora and vegetation dataset will continue to be updated as further survey work is undertaken and will be used as part of the Derived Proposal process to verify the expected impacts to flora and vegetation. The data will also be used to inform appropriate site-specific mitigation (if required) for Derived Proposals relevant to Jinidi mining hub.

Weeli Wolli Spring is considered a Tier 2 key asset as described in Section 6.2. Conservation-significant vegetation communities not formally recognised as a TEC or PEC, such as the calcrete community, are considered to be Tier 3 key assets, although the conservation-significant species that occur within the calcrete community (e.g. *Acacia subtiliformis* and *Goodenia* sp. East Pilbara) will be managed as Tier 2 key species. All of these key environmental assets and significant species would be managed in line with the objectives for each tier and with BHP Billiton Iron Ore's objectives for the relevant environmental factors (in this case, flora and vegetation). Mitigation measures specific to Jinidi would be provided in Derived Proposals for that mining hub to provide further assurance that implementation of the Strategic Proposal will be managed to an acceptable level and will meet the EPA's objective.



Jinidi vegetation association mapping

Avoidance through Informed Design

Often flora and vegetation of conservation significance can be avoided during the planning process. For example, there may be several locations available for roads, access tracks and infrastructure areas. Features such as OSAs can be designed to avoid flora and vegetation of conservation significance through site selection or infill of pits where practicable. This mitigation measure is a standard approach that BHP Billiton Iron Ore adopts during planning of all of its projects. For example, BHP Billiton Iron Ore was able to avoid a conservation-significant *Acacia* species through informed planning and design for Orebody 31 (see Case Study 2).

Case Study 2: Application of the mitigation hierarchy during scoping for Orebody 31

This case study demonstrates implementation of mitigation measures through the scoping phase to avoid and minimise potential impacts. BHP Billiton Iron Ore's Orebody 31 is located approximately 40 km east of Newman.

Site-specific flora and vegetation surveys (Onshore 2015) identified:

- Mulga (*Acacia aptaneura*) present as an upper-storey vegetation component, which may have local conservation significance due to its sensitivity to disturbance to sheet flow of surface water:
- The south-eastern sector of the disturbance footprint is capable of supporting groundwater-dependent vegetation and contains a species within a drainage line, *Eucalyptus victrix*, that was potentially at risk from groundwater drawdown associated with proposed dewatering at Orebody 31; and
- Four conservation-significant taxa: *Acacia* sp. East Fortescue (J. Bull and D. Roberts ONS A 27.01)

(Priority 1), *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3), *Goodenia nuda* (Priority 4) and *Acacia clelandii* (range extension).

Impacts to flora and vegetation were identified for Orebody 31 using the original design concept. BHP Billiton Iron Ore implemented a number of design changes and management controls to minimise the significance. of potential impacts. An example of the design changes and mitigation measures that were applied include:

- Utilisation of existing infrastructure and facilities at the adjacent Orebody 18 mining hub to reduce the proposal disturbance footprint by 25%.
- Modification of the Orebody 31 proposal footprint to avoid all known *Acacia* sp. East Fortescue populations, primarily through redesigning overburden storage areas (OSAs). BHP Billiton Iron Ore has also made a commitment to apply a 50-m buffer around these populations.
- Modification of the Orebody 31 proposal footprint to avoid the majority of identified habitat containing *Triodia* sp. Mt Ella (M.E. Trudgen 12739). This mitigation reduced the proposed clearing of *Triodia* sp. Mt Ella from 50 plants to seven plants.
- Modification of the Orebody 31 proposal footprint to avoid the majority of vegetation that has been rated as ‘Excellent’ condition. After mitigation, only 5.3% of vegetation in ‘Excellent’ condition remains within the Orebody 31 proposal footprint (reduced from 33.1%).
- Commitment to undertake visual monitoring of the health of *Acacia* sp. East Fortescue adjacent to high dust sources, including OSAs, on an ongoing basis. Corrective actions are proposed where monitoring identifies an impact.

The above examples provide an insight into the standard processes that BHP Billiton Iron Ore utilises during the scoping phase of project development. These processes will continue to be utilised during implementation of the Strategic Proposal.

Project Environment and Aboriginal Heritage Review

BHP Billiton Iron Ore utilises a spatial on-site management tool, known as the Project Environment and Aboriginal Heritage Review (PEAHR) procedure, across its operations for all ground-disturbing activities. The PEAHR is an electronic workflow process linked to a GIS that is used to approve all new land clearing on site. The PEAHR provides a mechanism to consider technical and professional advice regarding environmental, Aboriginal heritage, and land access planning and management issues where necessary. The objectives of the PEAHR are to:

- identify the significant environmental, Aboriginal heritage and land access aspects of BHP Billiton Iron Ore operations;
- ensure that, through appropriate environmental, Aboriginal heritage and land access planning and management, BHP Billiton Iron Ore’s project activities comply with all legislative and regulatory requirements, industry standards and codes of practice;
- minimise the number and nature of environmental, Aboriginal heritage and land access incidents and ensure the continued improvement of BHP Billiton Iron Ore’s environmental performance;
- provide improved planning and management at BHP Billiton Iron Ore’s projects and operations; and
- ensure that requirements of long-term planning, in particular closure and final rehabilitation, are taken into account at the planning stage.

The PEAHR process provides a robust system to ensure that environmental, Aboriginal heritage and land access requirements are considered before any ground-disturbance occurs. It provides a system that ensures that BHP Billiton Iron Ore’s commitments to avoid flora and vegetation of conservation significance are realised on the ground and that compliance performance against these requirements is achieved.

Vegetation and Species Monitoring

Vegetation monitoring is undertaken to build an understanding of impacts from operational activities such as dewatering. Monitoring can also inform management when results indicate that target levels are being approached, with mitigation measures adapted to ensure desired outcomes are met, and that exceedances of performance criteria are detected. It also allows for other changes in the environment (external impacts) to be detected.

BHP Billiton Iron Ore typically implements vegetation and species monitoring in conjunction with other forms of management. For example, the ecological function of many biological communities in the Pilbara is influenced by a specific hydrologic regime. BHP Billiton Iron Ore has completed ecohydrological studies of three areas close to its operations that support conservation-significant communities: Ethel Gorge, Coondewanna Flats, and Marillana Creek. These studies have incorporated many years of hydrological, geological, climatic and vegetation monitoring and baseline data to develop conceptual models that describe how each system functions. Modelling incorporates an adaptive management approach and will be improved as more data is collected over time. Importantly, these models underpin water management plans that detail how BHP Billiton Iron Ore will minimise potential impacts to the environment from associated operations, as well as allowing the advancement of adaptive management practices across the Company's riparian vegetation monitoring programs.

8.1.3.4 SIGNIFICANCE OF IMPACTS

The primary basis for the EPA's determination of the likely significance and acceptability of a proposal is whether it is likely to meet the EPA's objectives for each environmental factor. The EPA uses a significance framework to determine the likely significance of a proposal and to make decisions throughout the environmental impact assessment process, as outlined in EPA Environmental Assessment Guideline 9 (EPA 2015b). If the EPA considers that a proposal can meet all of its objectives, then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives, then its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives, then its effect on the environment is likely to be unacceptable.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework to determine whether the proposal can meet the EPA objectives for each environmental factor. For the purposes of evaluating significance, impacts to flora and vegetation were assessed using regional Beard (1975) vegetation mapping, predictive diversity modelling for vascular plants undertaken by CSIRO (Appendix 3) and locations of conservation-significant flora records across the Project Definition Boundary.

Impact to Extent of Vegetation Associations

An assessment of the potential impacts to Beard's (1975) Pilbara vegetation associations from direct impacts (i.e. clearing) is provided in Table 17 and shown in Figure 26 based on area calculations developed by Shepherd et al. (2001) and updated by DPaW (Government of Western Australia 2013).This table provides information on the 11 Beard (1975) vegetation associations mapped within the conceptual footprints for the 30% Conceptual Development Scenario and Full Conceptual Development Scenario.

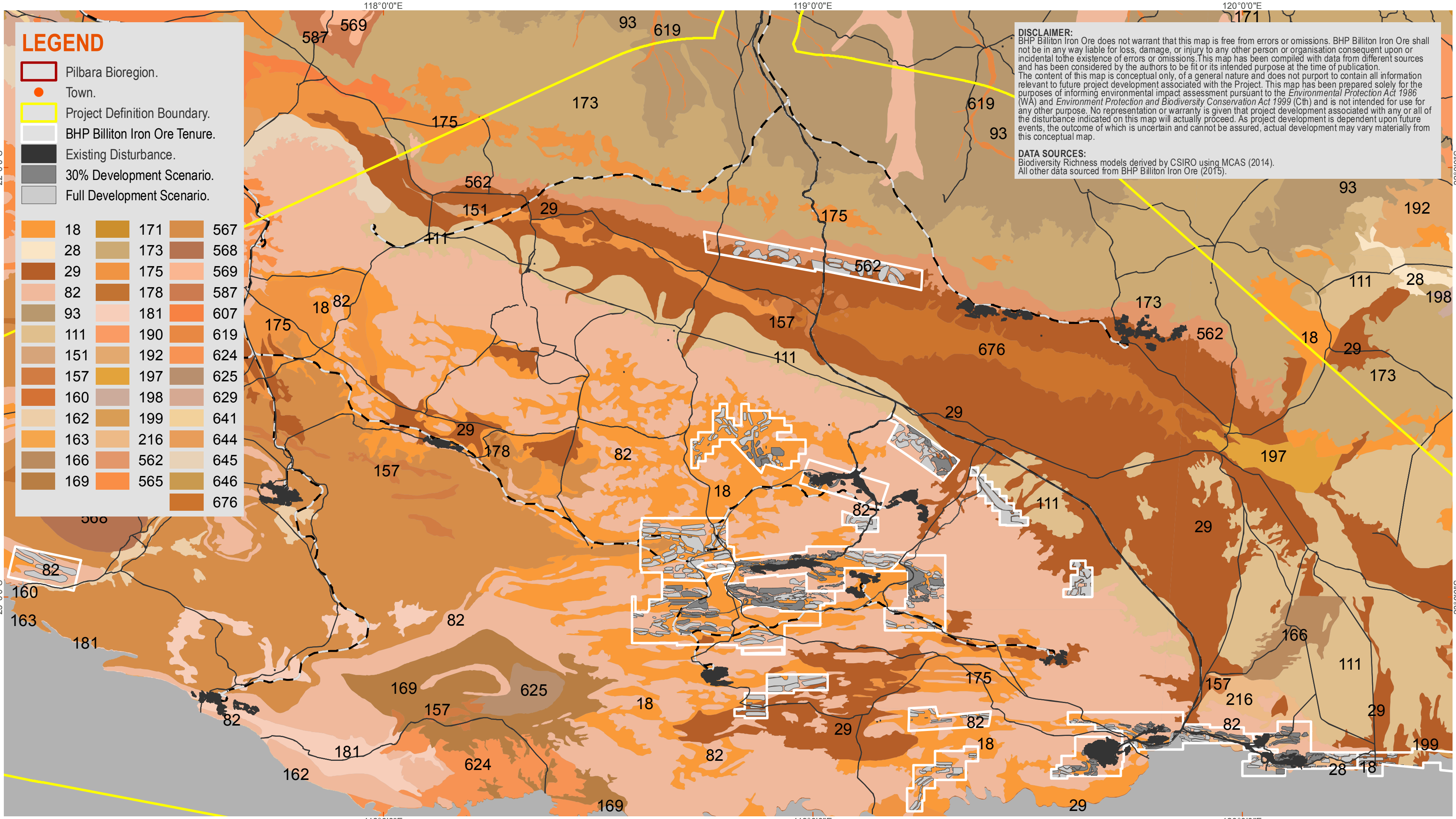


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Figure 26 Conceptual development scenarios relative to Beard (1975) vegetation associations

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Table 17: Cumulative impact assessment of BHP Billiton Iron Ore and third-party iron ore operations on Beard (1975) vegetation associations

Beard Vegetation Association	Pre-European Extent (ha)*	% of Association Remaining	Extent of Impact (ha) and % of area Pre-European Extent impacted[2]				Pre-European Extent remaining (%) after Full Conceptual Development Scenario
			Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
18**	676,557	99.39	3,434 (0.5%)	3,632 (0.5%)	20,245 (3.0%)	42,205 (6.2%)	93.15 %
29**	1,133,220	99.98	6,836 (0.6%)	31,55 (2.8%)	40,559 (3.6%)	51,707 (4.6%)	95.41 %
82	2,563,583	99.51	8,984 (0.4%)	12,001 (0.5%)	40,637 (1.6%)	75,862 (3.0%)	96.55 %
111**	550,287	99.99	535 (0.1%)	2,632 (0.5%)	3,924 (0.7)%	5,134 (0.9%)	99.06 %
173	1,752,521	99.72	124 (0.01%)	138 (0.01%)	386 (0.02%)	386 (0.02%)	99.70 %
175**	507,860	99.92	50 (0.01%)	0	99 (0.02%)	157 (0.03%)	99.89 %
216**	26,670	98.89	1,746 (6.6%)	0	5,282 (19.8%)	6,381 (23.9%)	74.96 %
562	103,607	100.00	1,933 (1.9%)	5,406 (5.2%)	7,398 (7.14%)	11,808 (11.4%)	88.60 %
567	776,824	99.66	508 (0.1%)	1,832 (0.2%)	2,341 (0.3%)	2,373 (0.3%)	99.36 %
676	92,364	99.93	18 (0.02%)	0	35 (0.04%)	35 (0.04%)	99.90 %

1. Data of pre-European extent and proportion (%) of association remaining from Government of Western Australia (2013).
2. Development Scenarios:

- Existing Development Scenario includes existing BHP Billiton Iron Ore and third party developments.
- Reasonably foreseeable third party includes future approved or proposed third party developments and does not include existing developments.
- 30% Conceptual Development Scenario includes existing development, reasonably foreseeable third party developments and BHP Billiton Iron Ore's 30% Conceptual Development Scenario.
- Full Conceptual Development Scenario includes existing development, reasonably foreseeable third party developments and BHP Billiton Iron Ore's Full conceptual Development Scenario

**. A vegetation association that extends beyond the Pilbara bioregion

The results provided in Table 17 indicate that two Beard vegetation associations may be impacted cumulatively to result in the total pre-European vegetation extent being less than 90%. These are:

- Vegetation Association 216: low woodland; mulga (with spinifex on rises); and
- Vegetation Association 562: mosaic - low woodland; mulga in valleys/snappy gum over *Triodia wiseana*.

Vegetation Association 216 occurs outside of the Pilbara bioregion and is common and widespread in the Pilbara region. The majority of future impacts to Vegetation Association 562 is from third party impacts, with BHP Billiton Ion Ore's future impact at 4.3% for the Full Conceptual Development Scenario (11.4% when existing and reasonable foreseeable third party are taken into account). BHP Billiton Iron Ore will validate cumulative impacts using the consolidated flora and vegetation mapping at the Derived Proposal stage.

Consolidated flora and vegetation mapping within BHP Billiton Iron Ore tenure provides a greater level of detail than the Beard (1975) vegetation mapping; however does not allow a regional-scale assessment given the extent of the mapping being restricted to BHP Billiton Iron Ore tenure. The consolidated mapping has highlighted that some mapped vegetation associations have a small (i.e., less than 20 ha) mapped extent across BHP Billiton Iron Ore tenure, or occur largely within the Full Conceptual Development Scenario footprint. These mapped vegetation associations are provided in Table 18.

Table 18: Mapped vegetation associations of restricted mapped extent or occurring largely within the Full Conceptual Development Scenario footprint

MAPPED VEGETATION ASSOCIATION	RESTRICTED MAPPED EXTENT[1]	GREATER THAN 70% FOOTPRINT OVERLAP[2]
CP EinTlBe Apr Es: Enneapogon Open Tussock Grassland	Yes	No
FP Aa Ch TtCfAco: Acacia High Shrubland	Yes	No
FP AayAaApt Tp Cc: Acacia Low Open Forest	Yes	No
FP AciAa Cc Bb: Acacia Low Open Forest	Yes	Yes
FP AlaEseApe SfSh: Aristida Open Tussock Grassland	Yes	No
FP EbEa Hl Acc: Eriachne Tussock Grassland	Yes	No
FP Ts Eg AayAaAca: Triodia Hummock Grassland	Yes	No
FP TscTp ExAaApr AteAscGw: Triodia Open Hummock Grassland	No	Yes
FP TtEaCc ChEx AdAaAmc: Themeda Tussock Grassland	No	Yes
FS Tw El: Triodia Hummock Grassland	Yes	No
GG AadAca AmuAaAte Tp: Acacia Low Open Forest	No	Yes
GP EbEf Aa Asy: Eriachne Tussock Grassland	Yes	No
GP SfScoGpr: Sida Very Open Herbs	Yes	Yes
HS AaAh Sgl TaTp: Acacia High Shrubland	Yes	No
HS Aci Efr Tw: Acacia High Open Shrubland	Yes	No
HS ArhEex Apr TsTw: Acacia Open Shrubland	Yes	No
HS Tb: Triodia Hummock Grassland	No	Yes

MAPPED VEGETATION ASSOCIATION	RESTRICTED MAPPED EXTENT[1]	GREATER THAN 70% FOOTPRINT OVERLAP[2]
HS TbrTw AiAprHc EfrEpl: Triodia Hummock Grassland	Yes	Yes
HS TmeTp AprAcaAmu CaEmu: Triodia Open Hummock Grassland	No	Yes
HS Tp AaGb AanAbAa: Triodia Hummock Grassland	Yes	No
MA Cc: *Cenchrus Tussock Grassland	No	Yes
MA ChEv ApyCci Cf: Corymbia Low Woodland	Yes	No
ME Ev PrPfmAbu Ecu: Eucalyptus Low Open Woodland	Yes	No
ME Gl Ev Sn: Glinus Herbs	Yes	No
ME TscTs Ch AadEloAan: Triodia Open Hummock Grassland	Yes	Yes
SA AChAprGs GstApaAan TbTsc: Corymbia Low Open Woodland	Yes	No
SP AaAprAx Eff Tp: Acacia Low Open Woodland	Yes	No
SP AprAa AiAb Ts: Acacia Low Woodland	Yes	Yes
SP ChEoCd AanApaAad TbTscTs: Corymbia Low Open Woodland	No	Yes
SP DrhThiPae: Dysphania Herbs	Yes	Yes

1. For the purposes of this document, a vegetation association is considered to have a restricted mapped extent if the mapped extent is under 20 ha.
2. For the purposes of this document, a vegetation association is considered to have potential for significant impact if more than 70% of the mapped extent of the vegetation association occurs within the Full Conceptual Development Scenario footprint. The 70% filter is used here for the purposes of highlighting those vegetation associations with the highest potential impacts, rather than a threshold for management.

The above information will be used at the Derived Proposal stage to validate vegetation community assemblages and associations and to define site specific management approaches. The data have been used at the Strategic Proposal stage to demonstrate that none of the above vegetation associations are located within areas formally recognised as PECs or TECs, so are considered to be Tier 3 Assets (refer to Section 6.2) for the purposes of management. In some cases, validation at the Derived Proposal stage may indicate that vegetation associations are representative of TECs, which would then be considered as Tier 1 or Tier 2 assets respectively. An example of the application of this approach is summarised in Case Study 1.

Given BHP Billiton Iron Ore's commitment to meet the objective for flora and vegetation, and the mitigation measures to avoid, mitigate and, where appropriate, offset residual impacts in line with the key regional asset management described in Section 6.2, BHP Billiton Iron Ore considers that impacts to conservation-significant vegetation associations will be managed to an acceptable level.

Impact to Vegetation Condition

The impact assessment for vegetation condition considered direct impacts from clearing from existing development, reasonably foreseeable third party mining projects and BHP Billiton Iron Ore Conceptual Development Scenarios. Where vegetation within the buffer areas was not mapped for vegetation condition, its impact was not included. Indirect impacts from land degradation caused by the introduction or spread of weeds, inappropriate fire regimes, and altered water regimes are discussed below. The cumulative assessment of direct impacts to vegetation condition is provided in Table 19 and illustrated in Figure 27a and b. Only 108,994 ha of the total 124,666 ha Full Conceptual Development Scenario footprint has been mapped for vegetation condition, representing approximately 87% of the Full Conceptual Development Scenario footprint. These unmapped areas include the proposed Roy Hill and Ministers North tenements, parts of Ophthalmia / Prairie Downs tenure and parts of the Newman mining hub. Given that the majority of the mapped areas represent Good to Excellent vegetation, it is likely that unmapped areas are also Good to Excellent.

Table 19: Area of potential direct impact to each vegetation condition category

Condition[1, 2]	Baseline mapped areas (ha)	Area cleared (ha)[3]		
		Existing Development Scenario	30% Conceptual Development Scenario	Full Conceptual Development Scenario
Completely degraded or cleared	12,884	10,297	10,512	10,627
Degraded	2,739	41	265	301
Good	30,802	405	1,298	4,864
Very good	124,449	2,055	10,410	21,750
Excellent	257,581	3,686	21,634	69,065
Pristine	7,779	0	464	2,387
Unmapped area	N/A	1,710	3,811	15,672
Total	***436,234***	***18,194***	***48,394***	***124,666***

1. Vegetation condition uses the Keighery (1994) scale.
2. Assessment based on mapped extents only and without mitigation (e.g. rehabilitation) in place.
3. Area cleared considers BHP Billiton Iron Ore impacts only, because vegetation condition is mapped only across BHP Billiton Iron Ore tenure. The 30% Conceptual Development Scenario and Full Conceptual Development Scenario includes Existing Development.

Vegetation of lower condition generally occurs in areas of lower relief within such habitats as ephemeral drainage lines, flood plains, stony plains and gilgai plains. Vegetation of highest condition generally occurs within BHP Billiton Iron Ore's eastern and central Pilbara tenure (broadly south of the Marillana lease), as well as in the narrow upper gorge habitats of the southern tenure (see Figure 27a and b).

Vegetation condition can be affected by the establishment of weeds through ecological processes such as competition with individual native flora thereby changing the flora assemblage, changing fire patterns, and increasing erosion. The potential for weed spread is likely to vary significantly, depending on the weed type (annual or shrub weed), the location of the weed source in relation to the remaining vegetation, and factors that may be beyond the control of BHP Billiton Iron Ore, such as pastoral and feral animal grazing, fires, flood events and climate change. For example, where weed sources are at low points in the landscape, or lower in the landscape in relation to remaining vegetation, the likelihood of some weeds spreading upslope is significantly less than downslope, and upslope vegetation is therefore less likely to be detrimentally impacted by weed introduction.

Weed control is a component of the Land and Biodiversity Management toolkit in Figure 17, and forms a part of routine operational activities within and adjacent to areas that have been cleared. Weeds are also a key consideration in rehabilitation monitoring to ensure that completion criteria for rehabilitated areas are met (refer to Section 8.5.2).

Potential impacts of hydrological change are discussed in Section 8.2. In summary, hydrological change can impact vegetation condition by causing:

- Vegetation health decline;
- Vegetation assemblage change;
- Modified drainage flow regimes;
- Increased water availability for riparian vegetation;
- Weed dispersal;
- Ground and surface water contamination;
- Exposure of ecosystems to toxic substances; and
- Degradation of groundwater resources.

Changes in vegetation condition from to hydrological change are managed through the Water Management toolkit described in Figure 42.

In terms of fire regimes, Pilbara vegetation is well adapted to fire with many species relying on fire to complete their life cycle (Carwardine et al. 2014). However, fire can be regarded as a threatening process which has the potential to negatively impact biological diversity (EPA 2006a), but which can also favour certain species under certain conditions. Cumulatively, it can be expected that fire will occur across the Pilbara, and it may have both positive and negative effects on biodiversity (and therefore vegetation condition). It is also likely that in the future there will be a relationship between climate change and fire regimes, which may further alter fire patterns, frequency and types in the Pilbara. With regard to reasonably foreseeable future impacts of fire, the effect of mining and non-mining activities on alteration of fire impacts is unclear and likely to be influenced primarily by assumptions of fire management and fire response. BHP Billiton Iron Ore considers that the Strategic Proposal is unlikely to impact upon fire regimes as these are largely independent of and would not be exacerbated by the Proposal. The Strategic Proposal is therefore unlikely to result in significant impact to flora and vegetation from a change in fire regime. Given the scientific uncertainties associated with the potential ecological impacts of climate change on flora and vegetation, it is not possible to meaningfully incorporate the impacts of climate change as part of the PERSP. BHP Billiton Iron Ore does recognise that such change is possible, and will incorporate climatic variation into its adaptive management approach and the verification and validation at the Derived Proposal stage.

Vegetation condition is one of the aspects that is considered in closure, rehabilitation and offsets planning. These aspects are described in Section 8.5.

Impact to Conservation-significant Flora

The impact assessment for conservation-significant flora was conducted using data supplied by DPaW in December 2015 and BHP Billiton Iron Ore's dataset. Species of interest were defined as any conservation-significant flora species that occurred within the Project Definition Boundary. A total of 128 species were identified as species of interest and are listed in Appendix 4.

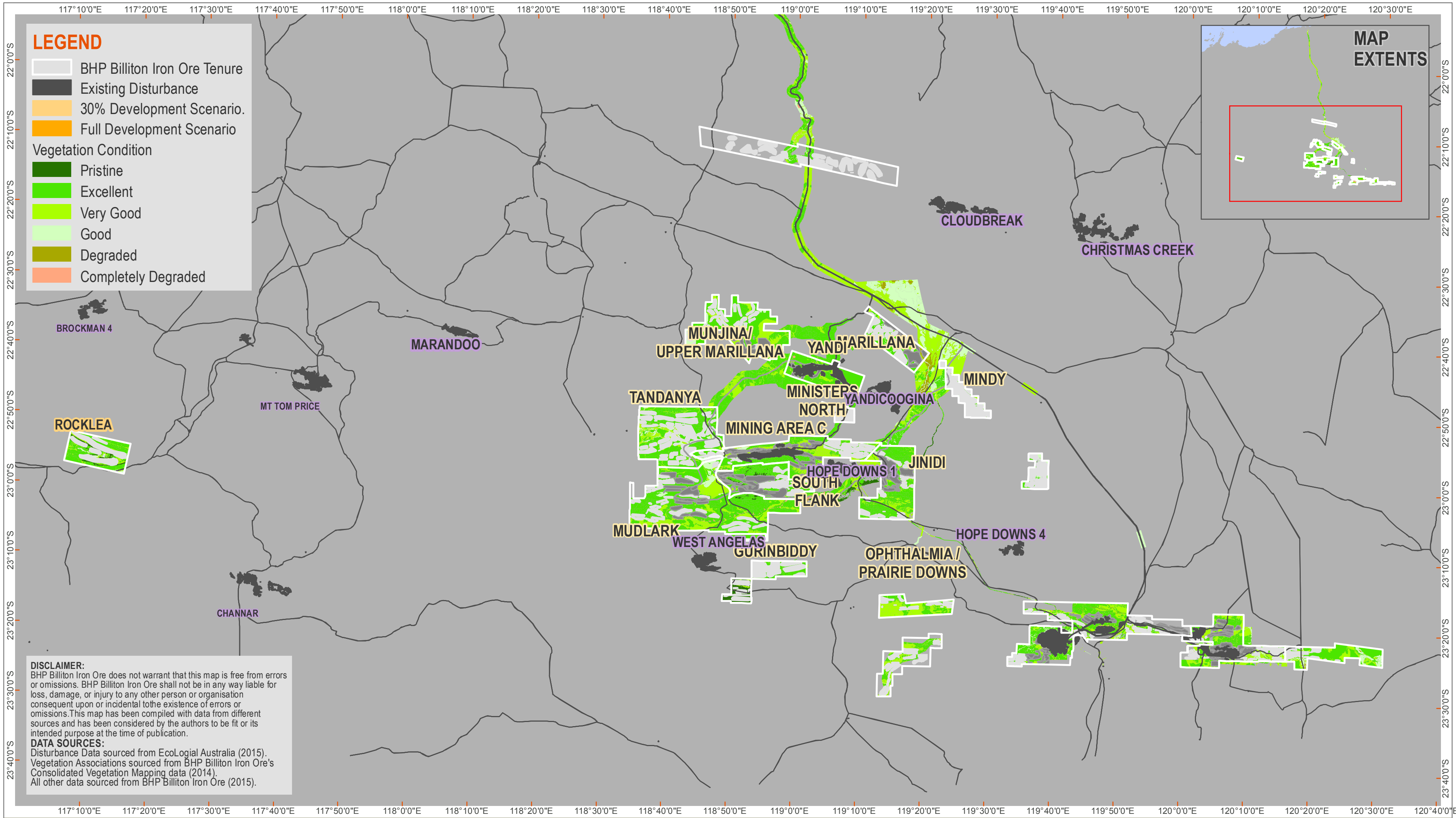
To determine flora species that have a higher potential to be impacted by the Strategic Proposal, the following criteria were applied to the 128 conservation-significant flora species occurring within the Project Definition Boundary.

- Known flora records potentially impacted by more than 10% from the development scenarios; or
- Known flora records that only occur within the Project Definition Boundary.

There are a number of national and state references that define threshold levels for vegetation, but there is none for impacts to species. A 10% threshold was considered a conservative approach to identify species likely to be at risk from implementation of the Strategic Proposal.

Fifty-one conservation-significant flora species were determined to have a higher potential to be impacted by the Strategic Proposal. The impacts to these species and the significance of impacts are described in Table 20. One species identified by the analysis, *Lepidium catapycnon*, is listed under the EPBC Act, has recently been delisted from the WC Act, and at a state level is considered a Priority 4 species. For the purposes of this document, *L. catapycnon* is considered a Priority 4 species. Its conservation significance is concurrently being assessed at a national level under the EPBC Act (360 Environmental 2015).

Known conservation-significant flora records relative to the development scenarios are shown in Figure 28. Those species that have been identified as having a moderate or high risk of impact from the Strategic Proposal are discussed further in text. All conservation-significant species that are considered of lower risk from the Strategic Proposal are listed and discussed in Appendix 4.



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Strategic Proposal

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0 5 10 20 30 40
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Figure 27a Cumulative impact on vegetation condition from development scenarios (overview)

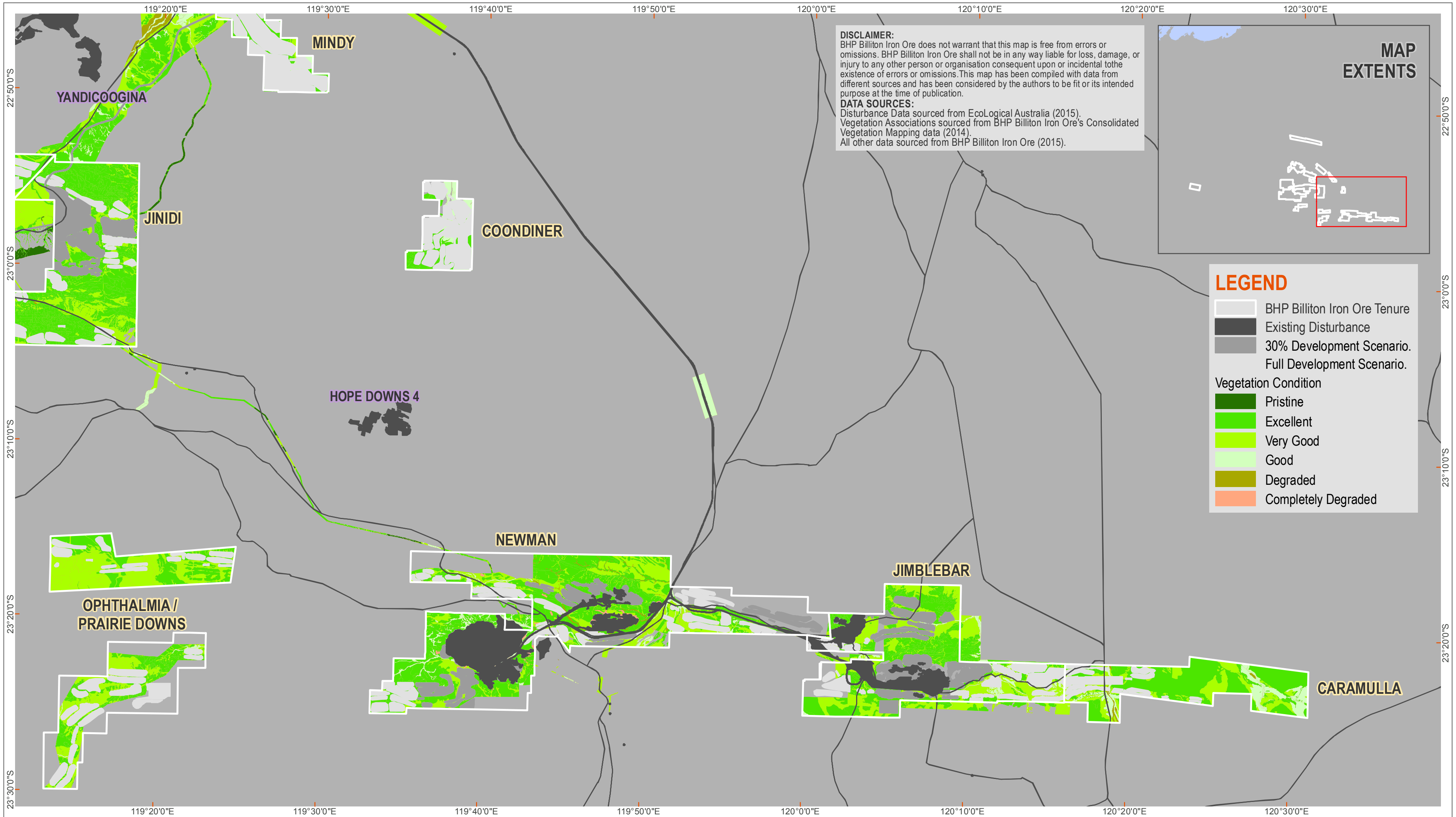

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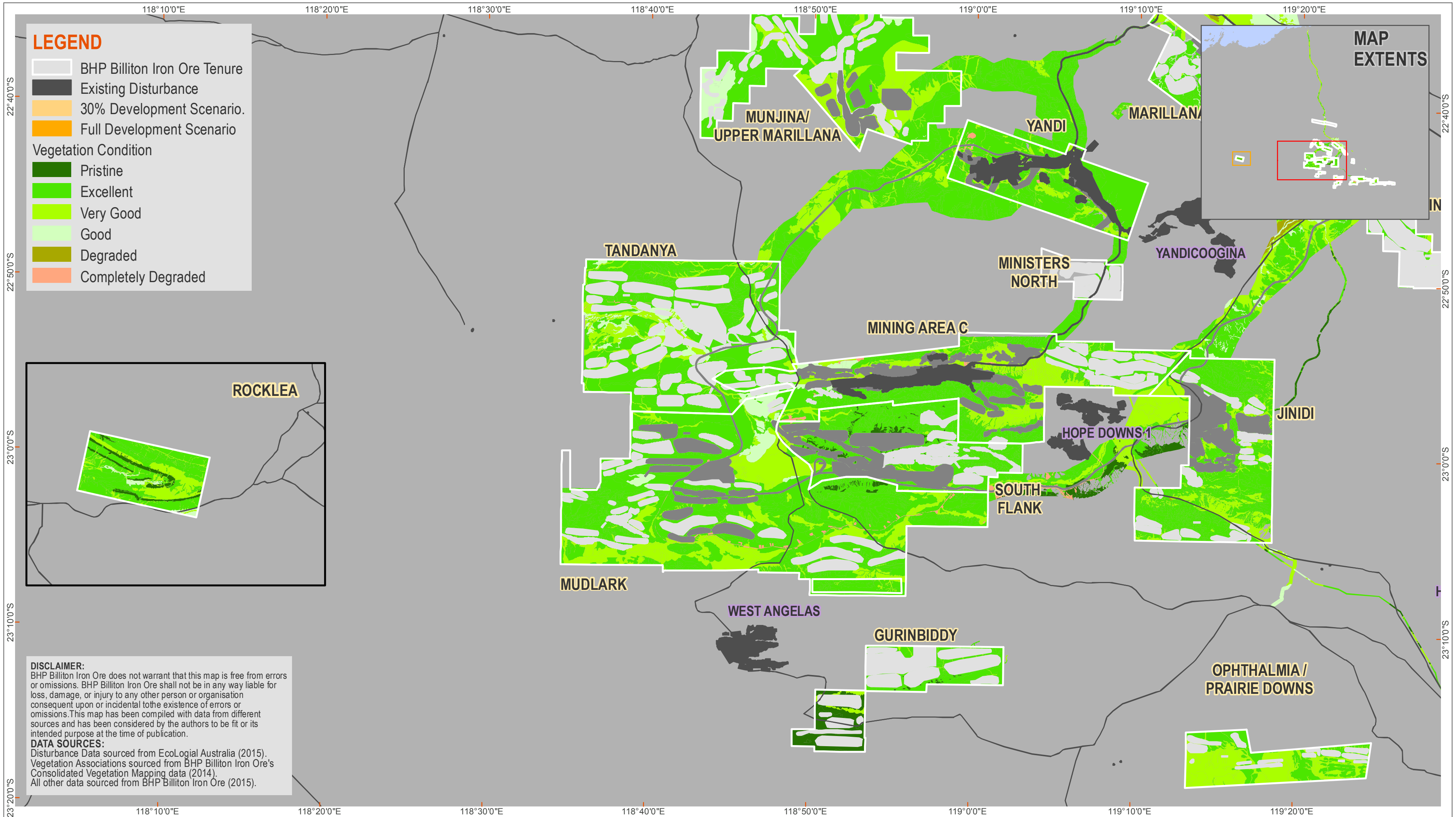
Figure 27b Cumulative impact on vegetation condition from development scenarios (east)



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Strategic Proposal

Figure 27c Cumulative impact on vegetation condition from development scenarios (central)

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0 2.5 5 10 15 20
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Table 20: Species description and distribution for WC Act conservation-significant species found exclusively within the Project Definition Boundary, or with greater than 10% of known records impacted by the Full Conceptual Development Scenario

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
TIER 2 - Priority 1								
Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)	97	97	97	0	0	0	0	A new taxon recorded within an area of approximately 8 ha adjacent to the north-west boundary of BHP Billiton Iron Ore's Orebody 31 tenement. Recent targeted surveys have failed to locate additional populations. Considered to be at high risk, noting that the current design and management at Orebody 31 will ensure no plants are disturbed.
Barbula ehrenbergii	4	4	4	0	0	0	0	Restricted to the central Pilbara but not previously recorded within the Full Conceptual Development Scenario footprints. Records occur within Karijini National Park. Risk considered to be low.
Calotis squamigera	4	4	4	0	0	1	1	Restricted to the South-East Pilbara including one third party tenement. Not previously recorded from BHP Billiton Iron Ore tenure. Risk considered low.
Eragrostis sp. Mt Robinson (S. van Leeuwen	10	10	10	0	0	0	0	Restricted to upper slopes of Mt Robinson where it occurs with a suite of other significant flora. The upper slopes of Mt Robinson is not included within BHP Billiton Iron Ore's Full Conceptual Development Scenario

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
4109)								footprint and therefore risk to this species is considered low.
Eremophila pilosa	9	9	9	0	0	0	0	Restricted to a small area in the Fortescue subregion of the Pilbara where it has been recorded growing on red-brown clays of sandy plains. Risk considered low.
Eremophila sp. Hamersley Range (K. Walker KW 136)	6	6	6	0	0	2	2	Restricted to the south-east Pilbara and extending into the northern fringe of the Gascoyne bioregion where it grows on open rocky slopes, gullies and rock faces associated with large hills and cliffs. Six records from the Pilbara with two occurring within the 30% Conceptual Development Scenario and Full Conceptual Development Scenario. Risk considered moderate.
Eremophila sp. Jigalong (B. Buirchell BB 204)	1	1	1	0	0	0	0	Restricted to the North-East Gascoyne (just outside boundary of the South-East Pilbara). Not within the Full Conceptual Development Scenario. Risk determined to be low.
Eremophila sp. Snowy Mountain (S. van Leeuwen 3737)	1	1	1	0	0	0	0	Restricted to one location on the southern fringe of the Pilbara bioregion where it was observed growing at the summit of a hill in skeletal soil. Not within the Full Conceptual Development Scenario. Risk determined to be low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Eremophila sp. West Angelas (S. van Leeuwen 4068)	7	7	7	0	0	0	0	Within BHP Billiton Iron Ore tenure it is restricted to the upper slopes of Mt Robinson, but also occurs within a small range extending to the southwest on Rio Tinto tenure, and southeast towards Newman. No records within the Full Conceptual Development Scenario footprints. Risk considered low.
Eremophila spongiocarpa	415	415	415	257	0	257	257	Endemic to the Fortescue Marsh but occurring extensively across the entire marsh area. Recorded along BHP Billiton Iron Ore's mainline rail, as well as from surrounding tenements on Fortescue Marsh held by BHP Billiton Iron Ore and FMG (Christmas Creek, Cloud Break). Extensive habitat available for this species within the marsh area. Records within Full Conceptual Development Scenario footprints are associated with already approved projects. Risk considered low.
Euphorbia inappendiculata var. *queenslandica*	8	7	4	1	0	1	1	Commonly recorded across the arid zones of the NT, Queensland, South Australia and NSW, but uncommon in WA where it is known from two areas in the Hamersley subregion of the Pilbara, and west of Halls Creek in the Kimberley. Risk considered low.
Hibiscus sp. Canga (P.J.H. Hurter & J.	4	4	4	0	0	0	0	Restricted to the southern fringe of the Pilbara bioregion in the vicinity of Paraburdoo, where it often grows in association with the Canga detrital formations. Not

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Naaykens 11013)								recorded within the Full Conceptual Development Scenario footprint. It is noted that a large number of WA *Hibiscus* specimens are still held in the eastern states of Australia and until they are returned the taxonomy of *Hibiscus* it is difficult to determine the full extent of occurrence of this species. Risk determined to currently be low.
Hibiscus sp. Mt Brockman (E. Thoma ET 1354)	5	5	5	0	0	0	0	Restricted to the central southern sector of the Pilbara bioregion in the vicinity of West Turner syncline where it occurs in sheltered or rocky drainage lines below cliff lines or rocky ridges. No records within the Full Conceptual Development Scenario footprints. Risk considered low.
Josephinia sp. Marandoo (M.E. Trudgen 1554)	17	17	16	0	1	5	5	Known from the Central and South-East Pilbara where it occurs on clay soils. Within BHP Billiton tenure it has been recorded within the Tandanya and South Jimblebar tenements. A number of records occur within 30% Conceptual Development and Full Conceptual Development Scenarios. The risk is considered moderate.
Myriocephalus scalpellus	3	3	3	0	0	0	0	Known from a single locality between Munjina and Roy Hill outside BHP Billiton Iron Ore tenure where it occurs within sandy loam or clay soils near clay pans. No

SPECIES	RECORDS			NUMBER OF RECORDS WITHIN DEVELOPMENT SCENARIOS[1]				SIGNIFICANCE OF IMPACT
	TOTAL[2]	PILBARA AREA[3]	PROJECT DEFINITION BOUNDARY	EXISTING DEVELOPMENT SCENARIO	REASONABLY FORESEEABLE THIRD PARTY	30% CONCEPTUAL DEVELOPMENT SCENARIO	FULL CONCEPTUAL DEVELOPMENT SCENARIO	
								records within the Full Conceptual Development Scenario footprints. Risk considered low.
Sida sp. Hamersley Range (K. Newbey 10692)	30	30	25	0	2	2	5	Restricted to the Hamersley Range of the Pilbara, predominantly in the vicinity of Tom Price. Records within the 30% Conceptual Development Scenario are from currently approved 3rd party projects, with an additional three records occurring within the Full Conceptual Development Scenario footprints. Risk is considered low.
Synostemon hamersleyensis	5	5	5	0	0	1	4	Restricted to the South-East Pilbara including Rio Tinto's Koodaideri tenements and BHP Billiton Iron Ore's Marillana tenement. Majority of records occur within the Full Conceptual Development Scenario footprints. Records available from BHPBIO and government databases do not reflect current knowledge of species distribution and numbers (discussed further in text of PERSP document). Risk considered high.
Tetratheca fordiana	7	7	7	0	0	0	0	Recorded from only a small area in the southern Hamersley subregion of the Pilbara. Occurs in shale pockets amongst ironstone. No records within in the Full Conceptual Development Scenario footprints. Risk considered low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Triodia sp. Karijini (S. van Leeuwen 4111)	21	21	21	0	0	0	0	Restricted distribution, with known records occurring around and within Karijini National Park approximately 150 km northwest of Newman. Has been recorded within BHP Billiton Iron Ore's Tandanya and Mudlark (on upper slopes of Mt Robinson) tenements. No records within the Full Conceptual Development Scenario footprints. Risk considered low.
Vittadinia sp. Coondewanna Flats (S. van Leeuwen 4684)	16	16	16	0	0	1	1	Restricted distribution east of Karijini National Park within and around the Coondewanna Flats. Infrequently recorded on BHP Billiton Iron Ore leases (Tandanya and Area C), possibly due to seasonality. Habitat described as clay soil in association with low woodlands, often with mulga. Risk considered low.
TIER 2 - Priority 2								
Aristida lazaridis	203	203	203	1	0	68	83	Occurs in the Pilbara and Kimberly regions of Western Australia and in the Northern Territory and Queensland. Recorded from a number of locations within BHP Billiton Iron Ore's Area C, Tandanya and Mudlark tenements in the Central Pilbara and 5 km north of Newman. In one of these locations it was the dominant ground cover. Apparently confined to sandy or loamy soils. A number of records occur within the 30% and Full Conceptual Development Scenario footprints (all restricted to BHP

SPECIES	RECORDS			NUMBER OF RECORDS WITHIN DEVELOPMENT SCENARIOS[1]				SIGNIFICANCE OF IMPACT
	TOTAL[2]	PILBARA AREA[3]	PROJECT DEFINITION BOUNDARY	EXISTING DEVELOPMENT SCENARIO	REASONABLY FORESEEABLE THIRD PARTY	30% CONCEPTUAL DEVELOPMENT SCENARIO	FULL CONCEPTUAL DEVELOPMENT SCENARIO	
								Billiton Iron Ore tenure), but this is likely an artefact of sampling. Risk considered low due to extent of distribution and presence within Karijini National Park.
Dicladanthera glabra	11	11	11	0	0	0	0	Recorded from only a small area in the Hamersley and Fortescue subregions of the Pilbara. Occurs in alluvium soils along watercourses and near rock pools. All currently known records are contained within the Project Definition Boundary, however there is no impact to these records from the overlay of the Full Conceptual Development Scenario footprint. Risk considered low.
Eremophila forrestii subsp. Pingandy (M.E. Trudgen 2662)	10	10	10	0	0	0	1	Known from the central southern sector of the Pilbara bioregion, but not previously recorded from BHP Billiton Iron Ore tenure. A single record from within the Full Conceptual Development Scenario footprints. Risk considered low.
Goodenia hartiana	29	12	10	1	0	6	6	Recorded predominantly from the Little Sandy Desert and Great Sandy Desert bioregions. Previous Pilbara-based records around BHP Billiton Iron Ore's Jimblebar tenements have been misidentified (correct identification was *Goodenia* sp. Sandy Creek). Risk determined to be very low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Hibiscus sp. Gurinbiddy Range (M.E. Trudgen MET 15708)	10	10	10	0	0	0	2	Recorded from breakaway slopes within BHP Billiton Iron Ore's Mudlark tenements. Current distribution restricted to the southeast Pilbara, but likely to be wider with additional survey work. Two records occur approximately 25 km apart within Karijini National Park. Risk considered low.
Indigofera ixocarpa	40	40	36	0	10	11	11	Previously recorded within third party mine tenure in the Chichester and Hamersley subregions of the Pilbara. Occurs in skeletal red soils over massive ironstone. No records from BHP Billiton Iron Ore tenure, although a number of records occur in the Full Conceptual Development Scenario footprints. Risk considered low.
Isotropis parviflora	54	53	53	3	0	24	27	Previously recorded from around BHP Billiton Iron Ore's Yandi, Marillana and Jinidi tenements and extending east to Newman where it is common in the Ophthalmia Range. It is also known from the Tanami Desert. It's a short-lived colonising species that is rapidly outcompeted. Large proportion of records within the Full Conceptual Development Scenario footprints, which likely reflects sampling bias given distribution of records. Risk considered moderate.
Oxalis sp. Pilbara (M.E.	15	14	14	0	0	2	8	Previously recorded from West Angelas Hill (Rio Tinto tenure), as well as from Tandanya and Mudlark leases

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Trudgen 12725)								(BHP Billiton Iron Ore tenure). Within the Pilbara it is restricted to the southern central Hamersley Ranges. There is one confirmed record from Mt Meharry in Karijini National Park, and one record from the Gascoyne approximately 265 km from the nearest Pilbara record. Large proportion of records within the Full Conceptual Development Scenario footprints, which likely reflects sampling bias given distribution of records. Risk considered moderate.
Scaevola sp. Hamersley Range basalts (S. van Leeuwen 3675)	23	23	23	0	0	0	4	Restricted to the Central Pilbara. Not previously recorded from BHP Billiton Iron Ore tenure during baseline surveys, but four records within third party tenure occur within the Full Conceptual Development Scenario. Risk considered low.
TIER 2 – Priority 3								
Acacia effusa	99	99	99	0	2	2	2	Known from a large number of records within the central southern sector of the Pilbara bioregion, including Karijini National Park. Habitat is described as lower scree slopes of low rocky ranges or alluvial plains at the base of banded ironstone ranges. It is often common where it occurs. Risk considered low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Acacia subtiliformis	645	645	645	0	2	36	90	Recorded extensively between Newman and Karijini National Park, a range of approximately 120 km east-west and 90 km north-south. Habitat specific occurring on rocky calcrete low hills and plains. Known from BHP Billiton Iron Ore's Yandi and Jinidi tenements, and occurring extensively on calcrete plains bordering Weeli Wolli Creek. A number of records occur within the 30% and Full Conceptual Development Scenario footprints. Impact considered low.
Aristida jerichoensis var. *subspinulifera*	231	227	227	1	0	20	37	Occurs in large numbers in NSW and QLD, with smaller populations in the NT, South Australia and WA. In WA, it has been recorded extensively west of Mining Area C and adjacent to the Great Northern Highway, extending onto Tandanya, Mudlark and South Flank leases. These are the largest populations represented on BHP Billiton Iron Ore tenure, but it is also recorded closer to Newman and extending out to Jimblebar leases and surrounds. Given the current range, the cumulative risk is considered low.
Dampiera anonyma	45	45	45	0	0	0	0	Known from 45 records within the central southern sector of the Pilbara bioregion, of which approximately half occur within Karijini National Park. No records within BHP Billiton Iron Ore tenure or the Full Conceptual Development Scenario footprints. Risk considered very low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Dampiera metallorum	68	68	68	0	0	0	5	Within BHP Billiton Iron Ore tenements restricted to upper slopes of Mt Robinson within the Mudlark tenements. Restricted to the Hamersley Ranges within (5 records) and east of Karijini National Park. Risk considered low.
Glycine falcata	14	11	6	0	0	0	2	Previously recorded between Karratha and Newman in the Pilbara, and also from the Kimberley, but also is widespread and common across the NT and Queensland with an isolated population in NSW. Two records occur within BHP Billiton Iron Ore tenure under the Full Conceptual Development Scenario. Risk considered low due to the wide distribution of the species.
Goodenia lyrata	34	26	26	0	2	3	4	Recorded from BHP Billiton Iron Ore's Tandanya, Jinidi and South Flank tenements. The distribution extends east and south outside the Pilbara bioregion to the NT border. The Pilbara populations are relatively localised, but conservation is enhanced by plants occurring within the Coondewanna Flats PEC boundary. Risk considered low.
Goodenia purpurascens	22	8	8	0	3	6	6	Recorded mostly in the Northern Kimberley and Victoria Bonaparte regions with another population in the Little Sandy Desert, but also widespread and common through the NT and Queensland. Records from the Project Definition Boundary were made during surveys for Hope Downs 4 (Mattiske 2008); these records are not within

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
								DPaW's database and are therefore not displayed on Florabase. Prefers clay or mud in swamps and seasonally wet depressions. Records in the Full Conceptual Development Scenario footprints are restricted the third party tenure. Risk considered low.
Goodenia sp. East Pilbara (A.A. Mitchell PRP 727)	1020	1020	1018	0	49	209	300	Regionally known from 16 localities between Paraburdoo and Mount Cooke. Recorded from BHP Billiton Iron Ore's Jinidi, Area C West to Yandi, and Yandi leases. It is habitat-specific, occurring on calcrete formations in close proximity to major drainage lines. Relatively widely distributed and common in suitable habitat within the southern Pilbara. Risk considered low to moderate.
Grevillea saxicola	97	97	97	0	0	1	3	Occurring east of Newman along the southern fringe of the Pilbara. Recorded from the eastern end of the Packsaddle Range, southern slopes of BHP Billiton Iron Ore's Jinidi tenements, and western fringe of Mt Robinson. Risk considered low.
Indigofera gilesii	158	152	152	0	0	19	35	Previously recorded at West Angelas Hill (Rio Tinto tenure) and at BHP Billiton Iron Ore's Tandanya and Jinidi leases, where it occurred on rocky hill tops and creeklines. Widely distributed within the southeast Pilbara (west of Newman) and represented in three other bioregions extending east to the Northern Territory border

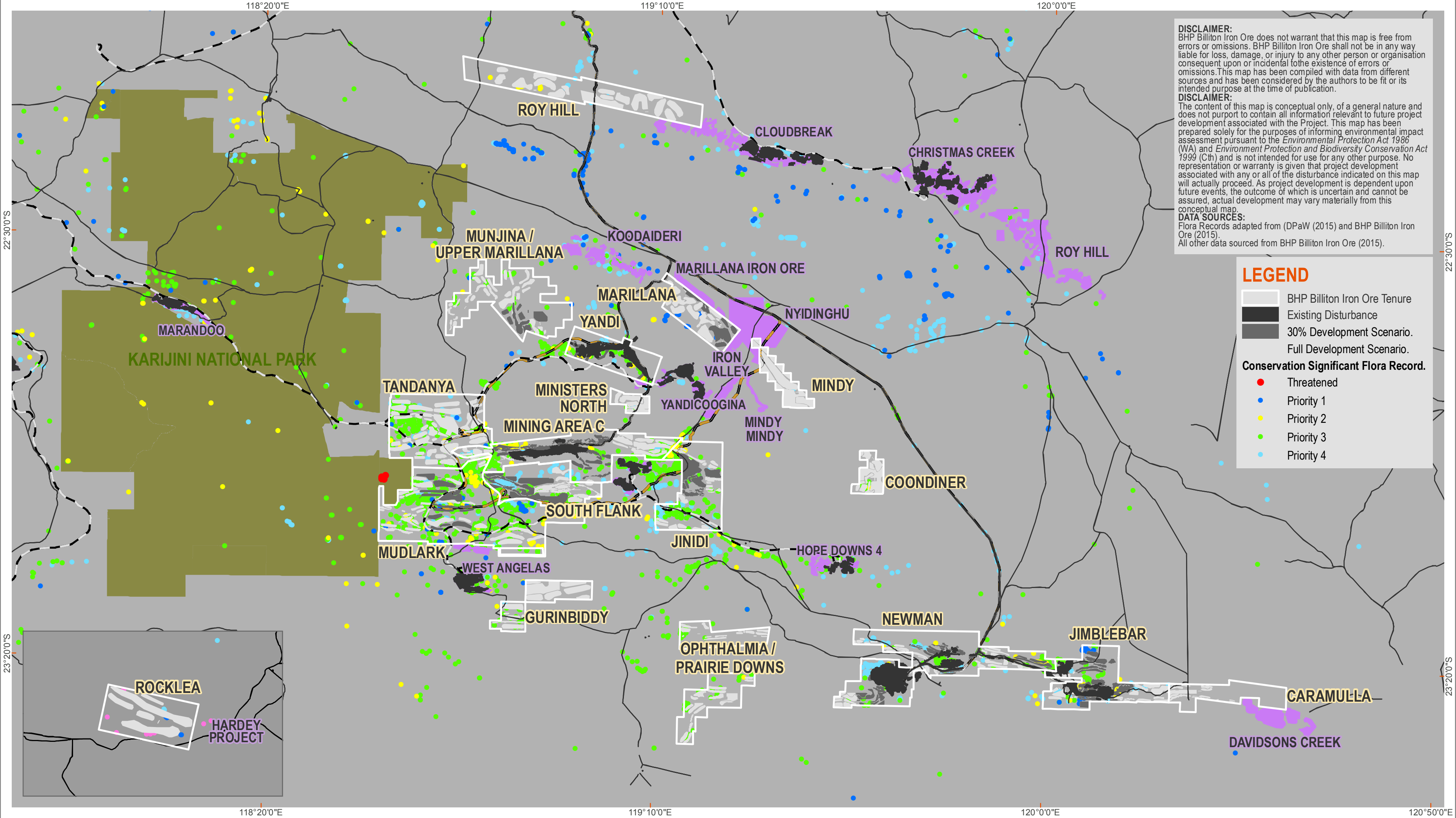
SPECIES	RECORDS			NUMBER OF RECORDS WITHIN DEVELOPMENT SCENARIOS[1]				SIGNIFICANCE OF IMPACT
	TOTAL[2]	PILBARA AREA[3]	PROJECT DEFINITION BOUNDARY	EXISTING DEVELOPMENT SCENARIO	REASONABLY FORESEEABLE THIRD PARTY	30% CONCEPTUAL DEVELOPMENT SCENARIO	FULL CONCEPTUAL DEVELOPMENT SCENARIO	
								and south to Wiluna. Any potential cumulative mining impact determined to be low.
Olearia mucronata	22	16	16	0	4	4	4	Occurs within the Murchison and Pilbara bioregions, extending over more than 850 km. Within the Pilbara has been recorded from the southern fringe of BHP Billiton Iron Ore's Mudlark tenement and considered very likely to occur within Karijini National Park. Risk considered low.
Pilbara trudgenii	35	35	35	0	0	0	0	Restricted to the south-east Pilbara, with records from Mt Robinson within BHP Billiton Iron Ore's Mudlark tenement. Prefers skeletal red stony soil over ironstone on hill summits, steep slopes, screes and cliff faces. No records within the Full Conceptual Development Scenario footprints. Risk considered low.
Rhagodia sp. Hamersley (M. Trudgen 17794)	1309	1309	1309	2	5	209	405	Recorded extensively over floodplains in western parts of Mining Area C, extending to Tandanya, Mudlark, South Flank and Jinidi tenements, all held by BHP Billiton Iron Ore. Also recorded around Newman and extending east to Jimblebar. Widely distributed taxon associated with mulga on floodplains. Few records occur within Karijini National Park, but additional records likely with additional survey work. Risk considered low to moderate.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Rostellularia adscendens var. latifolia	253	253	246	6	0	34	58	Recorded at BHP Billiton Iron Ore's Jinidi, Mining Area C, Tandanya, Mudlark and South Flank tenements. Occurs widely in drainage lines throughout the southern and eastern Pilbara. Also widespread and common across the NT, SA, NSW and Queensland. Risk considered low.
Sida sp. Barlee Range (S. van Leeuwen 1642)	130	130	125	1	0	10	39	Currently known from between Warrawagine and Tom Price. Five records occur within Karijini National Park. Recently recorded from BHP Billiton Iron Ore's Yandi, Mudlark and Tandanya tenements. Occurs extensively in gorges and steep rocky slopes throughout southern Pilbara and northern Gascoyne bioregions. Risk considered low.
Solanum kentrocaule	22	22	21	0	0	0	3	Occurs throughout the southern Pilbara and into the northern Gascoyne bioregions, with records from Mt Robinson within BHP Billiton Iron Ore's Mudlark tenements. A number of records occur within Karijini National Park. Risk considered low.
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	104	104	98	5	1	10	15	Extensively distributed within the southeast Pilbara and extending northwest to Karratha. It has previously been recorded at West Angelas (Rio Tinto) and occurs within the Coondewanna Flats PEC (Lake Robinson) on Tandanya tenements held by BHP Billiton Iron Ore. Potential to impact on known populations within the Full

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
								Conceptual Development Scenario, but risk considered low given extent of populations.
Triodia sp. Mt Ella (M.E. Trudgen 12739)	395	394	394	0	0	38	139	Previously recorded at West Angelas (Rio Tinto) from a range of landforms, including gorges, hill slopes and drainage lines, extending onto BHP Billiton Iron Ore's neighbouring Mudlark, Tandanya, Mining Area C, South Flank and Jinidi leases. Extends to the eastern end of the Ophthalmia Range near Jimblebar where it has most recently been recorded at the Wheelarra Hill North tenements. Risk considered low to moderate.
TIER 2 – Priority 4								
Eremophila magnifica subsp. *magnifica*	548	548	547	3	23	121	239	Frequently encountered on rocky slopes across the southern Pilbara bioregion and recorded from a majority of BHP Billiton Iron Ore tenements in southeast Pilbara, including Mining Area C, Marillana, Tandanya, Mudlark and South Flank, and with scattered records from Mount Whaleback extending east along Ophthalmia Range towards Jimblebar. Risk considered moderate.
Goodenia nuda	555	553	443	24	1	84	112	Widespread throughout the Pilbara, with records also from the northern Carnarvon and eastern Gascoyne bioregions. Recorded from a majority of BHP Billiton Iron Ore tenements in the Pilbara, with a large population

SPECIES	RECORDS			NUMBER OF RECORDS WITHIN DEVELOPMENT SCENARIOS[1]				SIGNIFICANCE OF IMPACT
	TOTAL[2]	PILBARA AREA[3]	PROJECT DEFINITION BOUNDARY	EXISTING DEVELOPMENT SCENARIO	REASONABLY FORESEEABLE THIRD PARTY	30% CONCEPTUAL DEVELOPMENT SCENARIO	FULL CONCEPTUAL DEVELOPMENT SCENARIO	
								known from Caramulla Creek and surrounds. Records occur within the Full Conceptual Development Scenario, but given the wide distribution and frequency at which populations have been recorded in the southeast Pilbara, the risk is considered low.
Lepidium catapycnon	1108	1108	1102	24	1	29	170	Broadly distributed between the Pilbara towns of Newman, Nullagine and Wittenoom. The total area of extent approximates 21,736 km^2 with eight known populations occurring within Karijini National Park. Increasing numbers of populations of *Lepidium catapycnon* have been recorded on BHP Billiton Iron Ore tenure, including Newman, Mining Area C, South Flank, Jinidi, Yandi, Marillana, and Mindy. At a state level, the conservation ranking for *Lepidium catapycnon* has recently been downgraded from Threatened (under the WC Act) to Priority 4 in response to the increasing frequency at which this taxon is being found. It is regarded as being relatively common across the southeast Pilbara region and well represented within Karijini National Park. Risk considered low.

1. Development Scenarios are defined in Section 7.4.
2. Total records represents the total number of records available for that species.
3. Pilbara area refers to a search area that encompasses the Project Definition Boundary. Refer to Appendix 4 for further detail.



Public Environmental Review
Strategic Proposal

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Figure 28 Cumulative impact to known locations of conservation-significant flora records from the development scenarios

As described in Table 20, two species are considered to be at high risk from the development, five species are considered to be at moderate risk and three are considered to be at low-moderate risk. This species are:

High Risk

- *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) – this species was recently discovered (2014) during surveys for a proposed mine at BHP Billiton Iron Ore's Orebody 31 project area. Additional studies were undertaken to identify further populations in the south-east Pilbara, Karijini National Park and western Pilbara where suitable habitat occurred (based on geology and landform) (Onshore 2015). Additional populations were not able to be located, and the current distribution is restricted to three populations adjacent to the Orebody 31 mine. These plants fall outside of the disturbance footprint and they are being managed to reduced secondary impacts (dust). BHP Billiton Iron Ore recognises that this species will require continued management as a Tier 2 species to meet the environmental objectives for flora and vegetation (refer to Section 8.1.1.1). BHP Billiton Iron Ore will apply mitigation measures from the Land and Biodiversity Management toolkit (Figure 17) to ensure that impacts to this species are managed to an acceptable level.
- *Synostemon hamersleyensis* (Priority 1) - this species has only recently been described (2015), and knowledge on the species occurrence and ecology is still evolving. Currently, publicly available data for this species indicates that five records occur within the vicinity of BHP Billiton Iron Ore's Marillana tenement. A recent survey (November 2015) undertaken for BHP Billiton Iron Ore recorded 28 locations within its Marillana tenement, and 21 locations outside of the tenement boundary (between Marillana and BHP Billiton Iron Ore's Yandi mine), which have been included in the analysis in Table 20. As of October 2013, Rio Tinto had recorded 4,341 individual plants (identified at that time as *Sauropus* sp. Koodaideri detritals) as part of their supporting studies for Koodaideri (Eco Logical 2014). Approximately half of these individuals were recorded within BHP Billiton Iron Ore's Marillana tenement, with the rest located in Rio Tinto tenure, of which one tenement has not been identified as a target for mining within the next 20 to 25 years (and therefore not considered within the reasonable foreseeable third party footprint). Given that *Synostemon hamersleyensis* may be impacted by approximately 50 % under the Full Conceptual Development Scenario, BHP Billiton Iron Ore recognises that this species will require considered management as a Tier 2 species to meet the environmental objectives for flora and vegetation (refer to Section 8.1.1.1). BHP Billiton Iron Ore will apply mitigation measures from the Land and Biodiversity Management toolkit (Figure 17) to ensure that impacts to flora species of conservation significance are managed to an acceptable level during implementation of the Strategic Proposal. BHP Billiton Iron Ore will validate that the objectives for flora and vegetation can be met as any future Derived Proposal referral at a local and regional scale using updated baseline data and considers detailed mine planning and design. Given the Company's commitment to meet the objectives for flora and vegetation and the mitigation measures in place to achieve these objectives, BHP Billiton Iron Ore considers that impacts to conservation-significant flora can be managed to an acceptable level.

Moderate Risk

- *Eremophila magnifica* subsp*. magnifica* (Priority 4)– 548 locations were identified for this taxon, with 126 (approximately 22 %) recorded within the 30 % Conceptual Development Scenario footprints (24 within BHP Billiton Iron Ore tenements) and 244 (approximately 44 %) recorded within the Full Conceptual Development Scenario footprints (142 within BHP Billiton Iron Ore tenure). This species is restricted to the Hamersley Ranges, but it extends over a distance of approximately 300 km. Approximately one third of this area occurs within Karijini National Park and there are a number of records from within it. It occurs on rocky slopes in open *Eucalyptus* and *Acacia* shrublands, often associated with *Triodia* hummock grassland. This habitat is typical of those that occur within areas targeted for mineral exploration and mining, which suggests that the high proportion of records within development footprints is in part an artefact of a sampling bias. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.

- *Eremophila* sp. Hamersley Range (K. Walker KW 136) (Priority 1) – six locations were identified for this taxon, of which two fall within BHP Billiton Iron Ore footprints of the 30 % and Full Conceptual Development scenarios. This species is currently only known from the southern Hamersley Range, where it extends across a distance of approximately 200 km. Although it hasn’t been recorded within Karijini National Park, there are records adjacent to the park from habitats that occur within it. It is considered likely that this species also occurs within the national park. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.
- *Isotropis parviflora* (Priority 2) - 53 locations were identified for this taxon with 24 (approximately 45 %) recorded within the 30 % Conceptual Development Scenario footprints and 27 (approximately 50 %) recorded within the Full Conceptual Development Scenario (all within BHP Billiton Iron Ore tenure). This species is currently only known from the northern fringe of the Hamersley Range, where it extends across a distance of approximately 200 km. Although it hasn’t been recorded within Karijini National Park, there are records either side of it (a distance of approximately 40 km) and so it is considered highly likely that this species also occurs within the national park. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.
- *Josephinia* sp. Marandoo (M.E. Trudgen 1554) (Priority 1) - 17 locations were identified for this taxon with five (approximately 30 %) recorded within the 30 % Conceptual Development Scenario and Full Conceptual Development Scenario footprints (two of these occur within BHP Billiton Iron Ore tenure). This species restricted to the central Hamersley Range, where it extends across a distance of approximately 200 km. There are a number of records within Karijini National Park. This species favours clay soils, so is unlikely to occur in habitats targeted for mineral exploration. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.
- *Oxalis* sp. Pilbara (M.E. Trudgen 12725) (Priority 2) - 14 locations were identified for this taxon, with two (approximately 13 %) recorded within the 30 % Conceptual Development Scenario footprints (one within BHP Billiton Iron Ore tenements) and eight (approximately 53 %) recorded within the Full Conceptual Development Scenario footprints (seven within BHP Billiton Iron Ore tenure). The majority of this species records occur within the Hamersley Range, with a small number of records also recorded from the Gascoyne bioregion, approximately 250 km from the nearest Pilbara record. It has been recorded from the western edge of Karijini National Park, and it is possible that it could also occur

within the Collier Range National Park. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.

Low-Moderate Risk

- *Goodenia* sp. East Pilbara (A.A. Mitchell PRP 727) (Priority 3) - 1020 locations were identified for this taxon, with 209 (approximately 20 %) recorded within the 30 % Conceptual Development Scenario footprints (158 within BHP Billiton Iron Ore tenements) and 300 (approximately 30 %) recorded within the Full Conceptual Development Scenario footprints (249 within BHP Billiton Iron Ore tenure). The majority of this species records occur within the Hamersley Range, with a small number of records also recorded north-east of the Fortescue Marsh, with the records covering an area of approximately 52800 km. It has not been recorded within Karijini National Park, but the park occurs within its range so it is likely to occur within it where there is suitable habitat. It is habitat-specific, occurring on calcrete formations in close proximity to major drainage lines. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.
- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (Priority 3) - 1309 locations were identified for this taxon, with 209 (approximately 16 %) recorded within the 30 % Conceptual Development Scenario footprints (200 within BHP Billiton Iron Ore tenements) and 405 (approximately 31 %) recorded within the Full Conceptual Development Scenario footprints (396 within BHP Billiton Iron Ore tenure). The majority of this species records occur within the Hamersley Range, with a small number of records also recorded north-east of the Fortescue Marsh, with the records covering an area of approximately 46400 km. It has been recorded within Karijini National Park. It is generally considered to occur within mulga woodlands on floodplains. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) - 394 locations were identified for this taxon, with 38 (approximately 10 %) locations recorded within the 30 % Conceptual Development Scenario footprints (35 within BHP Billiton Iron Ore tenements) and 139 (approximately 35 %) recorded within the Full Conceptual Development Scenario footprints (136 within BHP Billiton Iron Ore tenure). The majority of this species records occur within the Hamersley Range, with a small number of records also recorded in the Karlamilyi National Park which occurs in the Little Sandy Desert. The records extend over a distance of almost 400 km. It has not been recorded within Karijini National Park, but has been recorded in close proximity (less than 10km east of the boundary), so it is considered also likely to occur within it. It has been recorded from a wide range of landforms. BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora. The Derived Proposal process allows the validation of impacts to the species, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives

described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to this species can be managed to an acceptable level.

8.1.4 TERRESTRIAL FAUNA ASSESSMENT

8.1.4.1 EXISTING ENVIRONMENT

Species Assemblages and Habitats

The Pilbara Biological Survey, undertaken by the DPaW between 2002 and 2007, systematically studied the vertebrate and invertebrate fauna across the Pilbara bioregion using stratified and standardised survey techniques (see McKenzie et al. 2009 for overview). Fauna habitat maps were not produced as part of this work; however, assessments of habitat characteristics that influence species distribution were undertaken.

Gibson and McKenzie (2009) concluded that small ground-dwelling mammal fauna of the Pilbara region is still relatively intact (15% of the original mammal fauna is now extinct (McKenzie et al. 2009)), despite the fact that anthropogenic disturbances, such as altered fire regimes, pastoralism, mining and weed invasion, have been influencing the region's ecology for over a century.

The data suggested that substrate type had the greatest influence on distribution of small ground-dwelling mammal species, with some species preferring more sandy substrates (e.g. the little red kaluta, (*Dasykaluta rosamondae*)), while others prefer more rocky substrates (e.g. the common rock rat, (*Zyzomys argurus*)). Sixteen of the 18 species recorded during the Pilbara Biological Survey are known to be extant in conservation reserves. The remaining two species (the long-tailed dunnart (*Sminthopsis longicaudata*) and the Ooldea dunnart (*Sminthopsis ooldea*)) both occur outside the Pilbara region, and habitat for the long-tailed dunnart is present in Karijini National Park, although it has not yet been recorded there.

Like some other arid areas, the most abundant bird species in the Pilbara are widespread generalists, although foliage height diversity does influence bird species' diversity and assemblage composition; the lowest species richness occurs on saline muds with samphire, and the highest species richness was observed at riverine and claypan sites, where tall *Eucalyptus* or *Melaluca* trees occur (Burbidge et al. 2010). Woodland areas (mulga and eucalypt) support a number of species that are largely restricted to these habitat types, e.g. the grey honeyeater (*Conopophila whitei*), which is largely restricted to areas of mulga, and the barking owl (*Ninox connivens*), which only occurs where large river red gums and paperbarks occur (Burbidge et al. 2010) (e.g. along Weeli Wolli Creek).

The Pilbara region has one of the most diverse reptile assemblages in the world; and like the mammal fauna, community structure of herpetofauna was strongly linked to surface type: broad rock, clay, sand and loam categorisations had the greatest influence on assemblage composition (Doughty et al. 2011). A number of reptile species are endemic to the rocky ranges of the Pilbara or extend slightly beyond to nearby rocky outliers in the Gascoyne region (Doughty et al. 2011). These include geckos, such as the Priority 2 listed Pilbara barking gecko (*Underwoodisaurus seorsus*) and the Priority 1 listed Pilbara blind-snake (*Anilios ganei*). The Pilbara generally lacks large predatory reptiles (such as crocodiles), with the conservation-significant Pilbara olive python being the largest predatory reptile from the region. This species has a strong preference for riparian vegetation during warmer months when hunting for prey but utilises rocky habitats at other times of the year (Doughty et al. 2011). Frog assemblages of the Pilbara show similar biogeographic patterns to lizards and blind snakes (Doughty et al. 2011). There are currently 13 known frog species from the Pilbara, of which three are endemic (Doughty et al. 2011).

The DPaW have identified two Threatened Ecological Communities and eight Priority Ecological Communities within the Pilbara region (see Section 8.1.2). Those that have the greatest value to vertebrate fauna are those that contain permanent or near permanent water (e.g. Weeli Wolli Springs); however, it is noted that there are a number of areas containing permanent water that occur either within the conservation estate (e.g. Karijini National Park) or within pastoral or mining leases (e.g. Ophthalmia Dam, Koodaideri Spring). These are discussed further in Section 8.2.2.

Fauna habitat maps are developed routinely during vertebrate fauna surveys undertaken for BHP Billiton Iron Ore. These are generally developed at the local scale to assist in environmental impact assessment for mining approvals. In 2014, Biologic Environmental Survey reviewed and consolidated fauna habitat mapping within BHP Billiton Iron Ore tenure to develop a single regional GIS dataset and report. The consolidated dataset provides methodological and nomenclatural consistency across BHP Billiton Iron Ore’s tenure and is updated on an ongoing basis as more surveys are completed. Vegetation mapping (Onshore 2014) was used as a key input for fauna habitat mapping. Where the vegetation associations did not correlate with fauna habitats (e.g., Gorge/Gully), boundaries were based on aerial photography or data from previous surveys. Supplementary field assessments were undertaken to address gaps in baseline data or to ground-truth the results from earlier surveys if required.

The Department of Agriculture and Food Western Australia undertook an inventory and condition survey of the Pilbara region between 1995 and 1999, which comprised the identification and mapping of 102 land systems within 20 broad land types based on predominant biophysical features (landform, soils and vegetation associations) (van Vreeswyck et al. 2004). As fauna distribution is largely influenced by landforms, soils and vegetation, at a regional scale this can be used to determine likely species distributions (e.g. Biota 2014). An overview of land systems and land types is provided in Section 5.5.

Seventeen fauna habitat types were identified by Biologic (2014) within BHP Billiton Iron Ore’s Pilbara tenure. Their key habitat characteristics and distribution are detailed in Table 21, and their locations are shown in Figure 29a, b and c. An assessment of the relative value of each habitat for native fauna was undertaken using data obtained from DPaW in January 2014. Species records were overlaid in each fauna habitat to determine species richness and the presence of conservation-significant species. Those fauna habitats with the highest species richness were Crest/Slope, Drainage Areas, Sand Plain and Stony Plain (all had 90 or more species records). Those fauna habitats with the highest number of conservation-significant species were the Sand Plain, Sand Dune, Major Drainage Line, Granite Dome and Boulder Piles, Fortescue Marsh Samphire, Gilgai and Gorge/Gully habitats. It is noted however, that information on survey effort was not available, and so this is possibly influenced by unequal survey effort across different habitat types (i.e. those habitat types that have a smaller area would have less surveys undertaken within them).

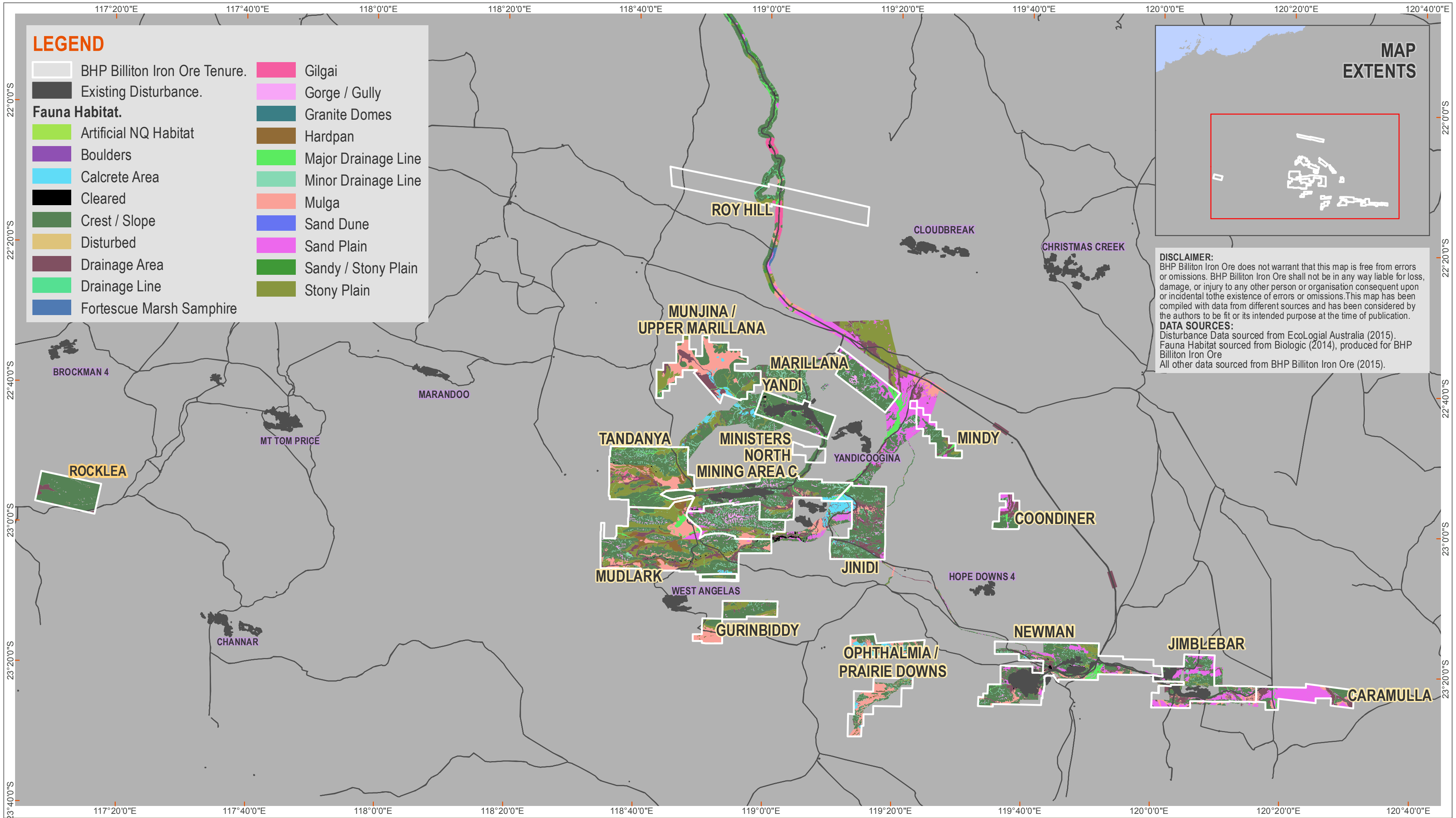

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Figure 29a Fauna habitat types across BHP Billiton Iron Ore tenure (overview)

0 5 10 20 30 40 50
Kilometres

N

bhpbilliton
resourcing the future

DATE: 12/02/2016
DRAWN: BHP Billiton Iron Ore Environmental Approvals

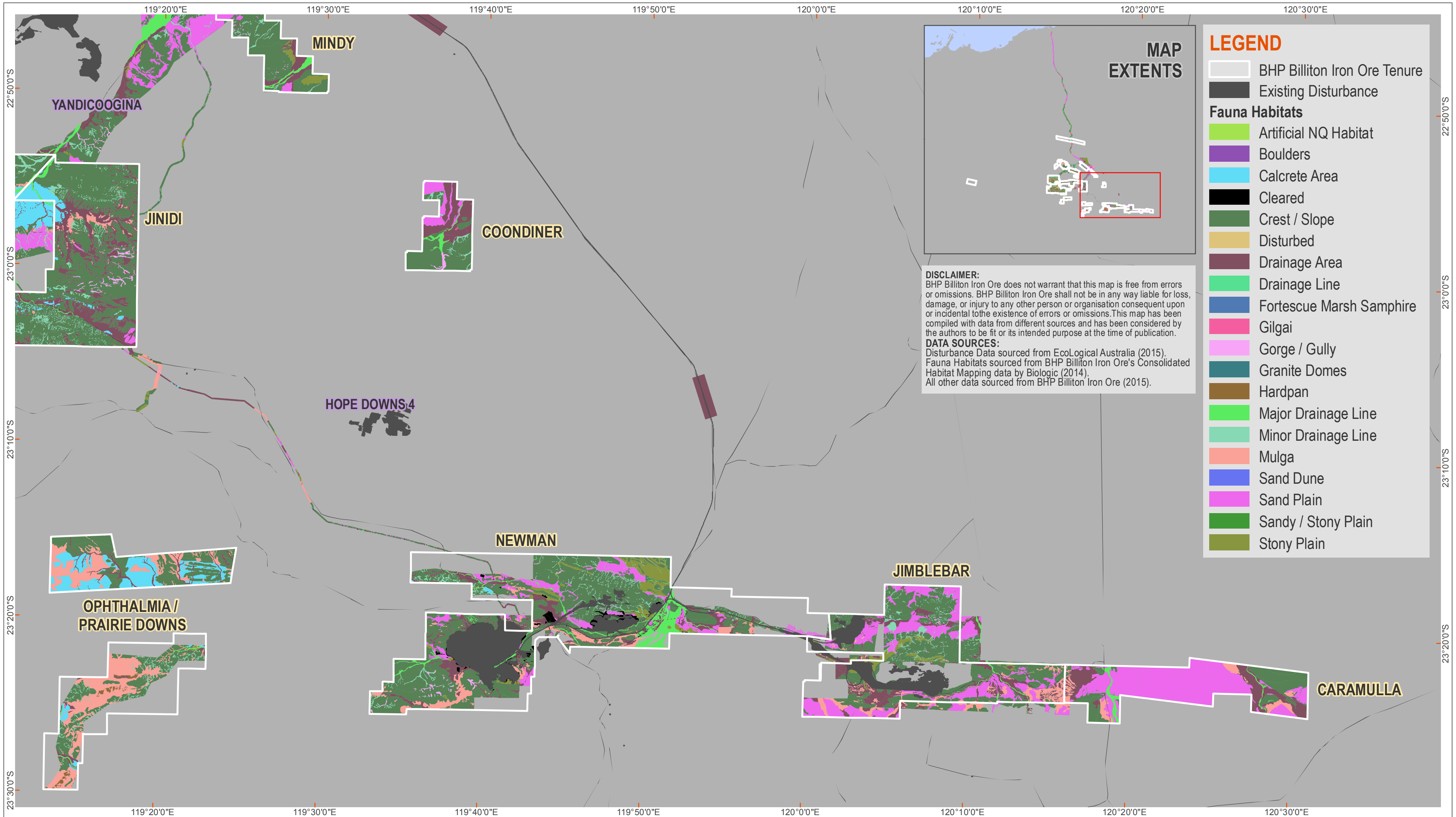

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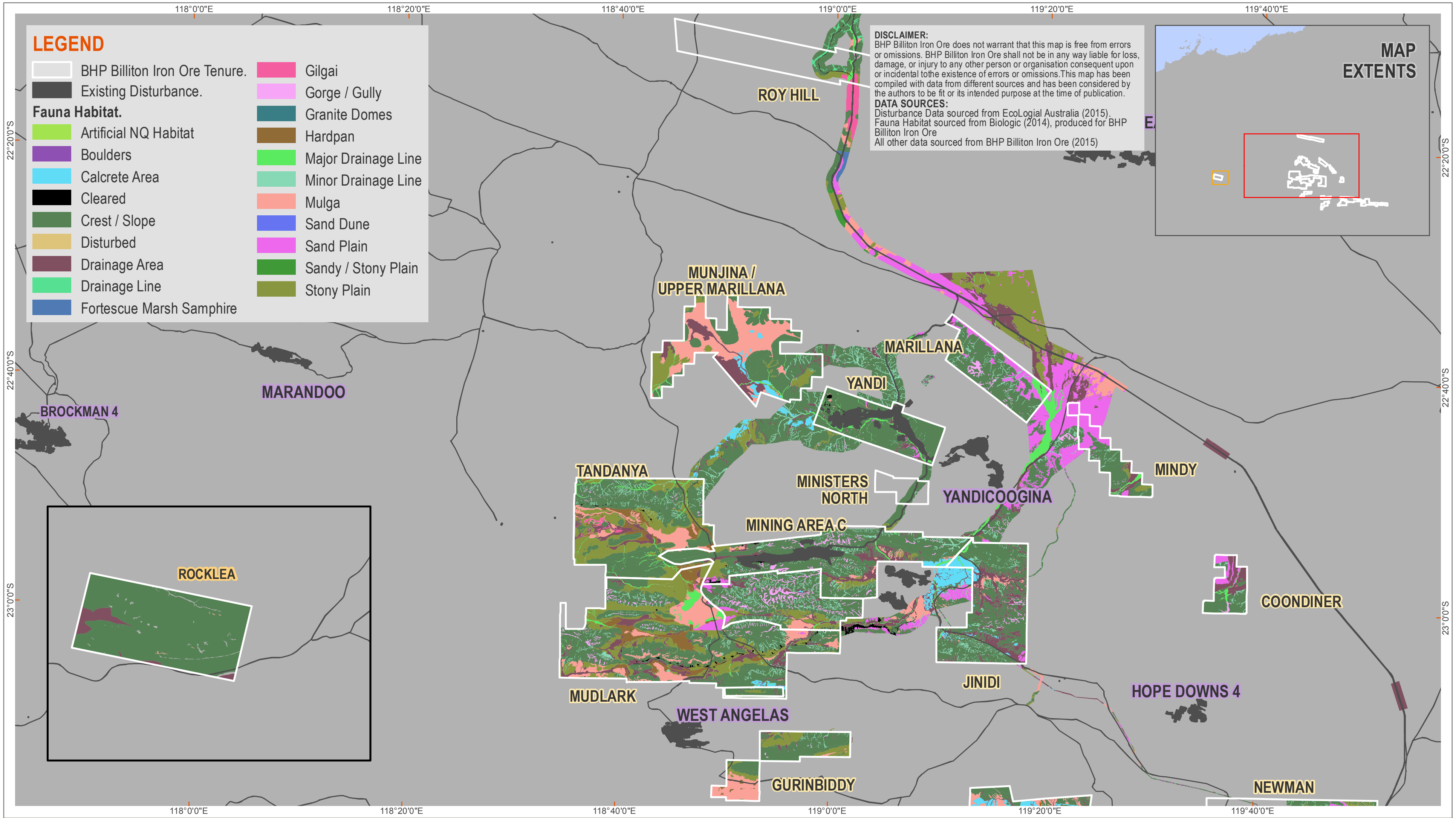
Figure 29b Fauna habitat types across BHP Billiton Iron Ore tenure (east)

0 2.5 5 10 15 20
Kilometres

N

bhpbilliton
resourcing the future

DATE: 12/02/2016
DRAWN: BHP Billiton Iron Ore Environmental Approvals



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Strategic Proposal

Figure 29c Fauna habitat types across BHP Billiton Iron Orel tenure (central)

bhpbilliton
resourcing the future

DATE: 12/02/2016
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Table 21: Fauna habitat types

FAUNA HABITAT	HABITAT CHARACTERISTICS	OCCURRENCE	EXAMPLES OF CONSERVATION-SIGNIFICANT SPECIES HABITAT USE	
			BREEDING	FORAGING
Plains				
Calcrete Areas	The vegetation occurring on calcrete differs from that of the surrounding areas, largely due to the differences in soil type. The substrate is white and consists of skeletal soil, gravel and small jagged pebbles. Trees are isolated, and the shrub layer tends to be sparse, with a low hummock grassland (*Triodia* spp.) dominant.	• This habitat is most common around Jinidi and Mining Area C, in particular in association with Weeli Wolli Creek. • An uncommon habitat type that is found throughout the Pilbara in small isolated areas. • Calcrete Areas are small in their total size when compared to other habitats. • Not well represented in national parks in the Pilbara.	• Western pebble-mound mouse (*Pseudomys chapmani*) – DPaW Priority 4; • Pilbara flat-headed blind snake (*Anilios ganei*) – DPaW Priority 1.	• Western pebble-mound mouse; • Pilbara flat-headed blind snake; • Ghost bat (*Macroderma gigas*) – WC Act Schedule 3, IUCN Vulnerable;
			No species are restricted to this habitat type, although the DPaW Priority 4 western pebble-mound mouse is known to build mounds in this habitat type.	
Gilgai (cracking clay)	Cracking clay soils usually contain weak crabhole (gilgai) microrelief and are generally saline at depth. Surface mantles are absent or common to abundant as pebbles and cobbles of ironstone, basalt and other rocks. Often associated with tussock grasses.	• There are two distinct locations for this habitat type: they are west of Mining Area C and just north of the Fortescue Marsh adjacent to BHP Billiton Iron Ore's mainline rail. • An uncommon habitat in the Pilbara. Areas of this habitat occur north of the marsh and along the coast near Karratha. • Not well represented within national parks in the Pilbara.	• Short-tailed mouse (*Leggadina lakedownensis*) – DPaW Priority 4	• Short-tailed mouse; • Ghost bat;
			The short-tailed mouse is considered to be largely restricted to this habitat type. Other near-endemic fauna in this habitat include the pebble dragon (*Tympanocryptis cephalus*) and Pilbara stone gecko (*Diplodactylus mitchelli*). Gilgai habitat occurs in a number of locations throughout the Pilbara; however, it is generally isolated and spatially small.	
Granite Domes and Boulders (tors)	This habitat occurs where the surrounding material has eroded, exposing large granite domes and boulders. Boulder piles and exfoliating	• The habitat occurs mostly adjacent to BHP Billiton Iron Ore's mainline rail, where it has historically been used for quarrying. • This habitat is reasonably common,	• Ghost bat; • Northern quoll (*Dasyurus hallucatus*) – EPBC Act Endangered, WC Act Schedule 2; IUCN	• Northern quoll; • Long-tailed dunnart; • Pilbara olive python; • Pin-striped fine-snout ctenotus.

Fauna Habitat	Habitat Characteristics	Occurrence	Examples of Conservation-significant Species Habitat Use	
			Breeding	Foraging
	rock on the granite domes provide excellent crevices and cracks for fauna to inhabit. Vegetation is sparse through these areas due to the lack of soil. Granite Domes and Boulders are mapped separately but combined together in this table. They are almost always surrounded by sand plains.	although patchily distributed, throughout the northern Pilbara. Granite domes and boulders tend to comprise isolated features in the landscape, varying in size, height and connectivity; thus, some patches could be considered more important than others. • Not well represented in national parks in the Pilbara.	Endangered; • Long-tailed dunnart (*Sminthopsis longicaudata*) – DPaW Priority 4; • Pilbara olive python (*Liasis olivaceus barroni*) – EPBC Act Vulnerable, WC Act Schedule 3; • Pin-striped fine-snout ctenotus (*Ctenotus nigrilineatus*) – DPaW Priority 1.	
			Boulder piles provide permanent and temporary refuges to an array of species inhabiting an otherwise fairly open matrix. Granite boulder piles provide either temporary or occasional denning habitat or core denning habitat supporting resident northern quoll populations depending on their size and complexity. Granite Domes provide important foraging and denning habitat for the northern quoll. The skink *Ctenotus nigrilineatus* is known from this habitat type. The Pilbara olive python is also known from this habitat.	
Hardpan Plain	Gently inclined alluvial plains with shallow loams. Sometimes covered by low scattered woodlands of mulga. In areas where the hardpan is close to the surface and soil depth is insufficient to support trees, an open scrub may persist.	• This habitat occurs mostly in BHP Billiton Iron Ore's Mudlark tenement and west of Mining Area C. • Common habitat throughout the Pilbara, particularly within and south of the Hamersley Range. Occurs within national parks in the Pilbara.	No significant species expected to breed in this habitat.	• Eastern great egret (*Ardea modesta*) – EPBC Act Migratory, WC Act Schedule 5; • Other EPBC Act–listed migratory waders.
			When inundated, hardpans may provide habitat for waterbirds.	

Fauna Habitat	Habitat Characteristics	Occurrence	Examples of Conservation-significant Species Habitat Use: Breeding	Examples of Conservation-significant Species Habitat Use: Foraging
Mulga	This habitat includes woodlands and other ecosystems in which mulga is dominant, either as the principal *Acacia* species or mixed with others.	• This habitat is situated in most of BHP Billiton Iron Ore's leases, including around Mining Area C. • Common habitat throughout the central and southern Pilbara. Mulga woodlands cover much of the region and extend south and east across the central arid zone of the continent. • Occurs within national parks in the Pilbara.	• Pilbara flat-headed blind snake; • Spotted ctenotus (*Ctenotus uber johnstonei*) – DPaW Priority 2. Mulga provides habitat for several species of conservation significance but none are restricted to this habitat type. However, mulga does support a relatively unique and diverse faunal assemblage, with numerous species restricted to this habitat type.	• Pilbara flat-headed blind snake; • Spotted ctenotus.
Sand Dune	Linear ridges of loose sand supporting similar species to the surrounding sandplains, dominated by *Triodia* spp. grasslands and areas of *Acacia* spp. shrubland occurring just south of the Fortescue Marsh.	• This habitat is situated in BHP Billiton Iron Ore's Marillana tenement and adjacent to BHP Billiton Iron Ore's mainline rail. • Limited extent outside of BHP Billiton Iron Ore tenure in the Pilbara, but common in desert regions to the east. A dune field exists to the east of BHP Billiton Iron Ore's Coondiner and Caramulla tenements. • Not represented in national parks in the Pilbara.	• Greater bilby (*Macrotis lagotis*) – EPBC Act Vulnerable, WC Act Schedule 3, IUCN Vulnerable; • Brush-tailed mulgara (*Dasycercus blythi*) – DPaW Priority 4. Dune systems provide potential habitat for the greater bilby, burrows for mulgara, and foraging habitat for both these species.	• Greater bilby; • Brush-tailed mulgara.
Sand Plain	Sand Plain habitat is characterised by relatively deep sandy soils supporting dense spinifex grasslands and sparse shrubs. This habitat transitions into patches of mulga in places. This habitat often occurs as terraces along Major Drainage Lines.	• This habitat is situated adjacent to BHP Billiton Iron Ore's mainline rail and southeast towards BHP Billiton Iron Ore's Carramulla tenement. • Common habitat throughout the Pilbara, especially in the north. Sand Plain areas are the predominant habitat type in the Chichester subregion.	• Greater bilby; • Brush-tailed mulgara; • Night parrot (*Pezoporus occidentalis*) – EPBC Act Endangered, WC Act Schedule 1, IUCN Endangered. Sand Plain is considered important breeding and foraging habitat for the	• Greater bilby; • Brush-tailed mulgara; • Night parrot.

Fauna Habitat	Habitat Characteristics	Occurrence	Examples of Conservation-significant Species Habitat Use	
			Breeding	Foraging
		• Not well represented in national parks in the Pilbara.	greater bilby and possibly the night parrot.	
Sandy/ Stony Plain	These are predominantly stony plains with localised depositions of sand that occur low in the landscape.	• This habitat is primarily located adjacent to BHP Billiton Iron Ore's mainline rail. • Common habitat throughout the Pilbara, especially in the north. • Occurs within national parks in the Pilbara.	• Greater bilby; • Brush-tailed mulgara; • Night parrot.	• Greater bilby; • Brush-tailed mulgara; • Night parrot.
			This habitat type is favoured by many species as burrows can be dug in areas of sand deposition.	
Stony Plain	These are erosional surfaces of gently undulating plains, ridges and associated footslopes. Mainly supports hard spinifex (and occasionally soft spinifex) with a mantle of gravel and pebbles.	• Common within BHP Billiton Iron Ore tenure, particularly in the northern areas adjacent to BHP Billiton Iron Ore's mainline rail. • Common habitat throughout the Pilbara, especially in the north. • Occurs within national parks in the Pilbara.	• Spectacled hare-wallaby (*Lagorchestes conspicillatus leichardti*) – DPaW Priority 3; • Night parrot; •	• Greater bilby; • Brush-tailed mulgara; • Spectacled hare-wallaby; • Night parrot; • Oriental plover (*Charadrius veredus)* – EPBC Act Migratory, WC Act Schedule 5..
			Despite several species utilising this habitat, none are largely restricted to this habitat type. Some significant species are unable to burrow into this substrate and therefore are less likely to breed in this habitat.	
Ranges				
Crest/Slope	Occurs high in the landscape and vegetation is generally more open and structurally simple than other fauna habitats. A common feature of these habitats is a rocky substrate, often with exposed bedrock, and skeletal red	• This habitat is found within most of BHP Billiton Iron Ore's leases, particularly in association with the Hamersley Range. • Extensive areas of Crest/Slope habitat occur throughout the Pilbara. • Occurs within national parks in the Pilbara.	• Pilbara flat-headed blind snake; • Western pebble-mound mouse.	• Pilbara flat-headed blind snake; • Western pebble-mound mouse; • Ghost bat; • Northern quoll; • Pilbara leaf-nosed bat (*Rhinonicteris aurantia*) – EPBC Act Vulnerable, WC Act

Fauna Habitat	**Habitat Characteristics**	**Occurrence**	**Examples of Conservation-significant Species Habitat Use**	
			Breeding	**Foraging**
	soils. Usually dominated by *Eucalyptus* woodlands, *Acacia* and *Grevillea* scrublands and *Triodia* spp. low hummock grasslands.			Schedule 3; • Pilbara barking gecko (*Underwoodisaurus seorsus)* – DpaW Priority 2.
			No EPBC-listed species are restricted to this habitat type, although the DPaW Priority 4 western pebble-mound mouse is largely restricted to this habitat type within the Project Definition Boundary. This habitat is very common in the region.	
Gorge/ Gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as the Minor Drainage Lines). Caves and rock pools are most often encountered in this habitat type. Vegetation can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred.	• The habitat occurs in most of BHP Billiton Iron Ore's leases where large hills and ranges occur, such as near Mining Area C and Jimblebar. • A reasonably widespread habitat in the Pilbara; however, because this habitat type is narrow and linear, it only represents a small proportion of the total land area. • Occurs within national parks in the Pilbara.	• Ghost bat; • Northern quoll; • Long-tailed dunnart; • Pilbara olive python; • Pin-striped fine-snout ctenotus; • Pilbara barking gecko; • Pilbara flat-headed blind snake; • Northern brushtail possum (*Trichosurus vulpecula arnhemensis*) – WC Act Schedule 3.	• Northern quoll; • Long-tailed dunnart; • Pilbara olive python; • Pin-striped fine-snout ctenotus; • Pilbara barking gecko; • Pilbara flat-headed blind snake; • Northern brushtail possum.
			Gorge/Gully habitat provides potential breeding, shelter and foraging sites for the Pilbara olive python, ghost bat and possibly Pilbara leaf-nosed bat. This habitat could also provide temporary roosts and transitional habitats for other bats. Gorge/Gully areas provide habitat for the Pilbara flat-headed blind snake and rainbow bee-eater (*Merops ornatus*), although neither of these species is restricted to this habitat type. Gorges and gullies are day time retreats for other larger mammals and reptiles.	

Fauna Habitat	Habitat Characteristics	Occurrence	Examples of Conservation-significant Species Habitat Use	
			Breeding	Foraging
Minor Drainage Line	Located in minor gullies and depressions, generally within the Crest/Slope habitat. Consists primarily of *Acacia* low shrublands. The understorey generally consists of sparse tussock grassland, including the weed buffel grass (*Cenchrus ciliaris*). The substrate can be sandy in places but generally consists of a skeletal loam gravel or stone.	• This habitat occurs in most of BHP Billiton Iron Ore's leases. • Common habitat throughout the central and southern Pilbara. Mostly associated with the Hamersley and Chichester ranges. • Occurs within national parks in the Pilbara.	• Pilbara olive python; • Rainbow bee-eater (*Merops ornatus*) – EPBC Act Migratory, WC Act Schedule 5; • Pilbara barking gecko.	• Pilbara olive python; • Northern quoll; • Pilbara leaf-nosed bat; • Rainbow bee-eater; • Cattle egret (*Ardea ibis)* – EPBC Act Migratory, WC Act Schedule 5; • Eastern great egret; • Pilbara barking gecko; • Northern brushtail possum.
			Minor Drainage Lines have the potential to provide habitat for a number of conservation-significant fauna, but these species are not restricted to this habitat type. Due to the general lack of tall, hollow-bearing trees, most Minor Drainage Lines are not commonly used for nesting. Some species may utilise this habitat transiently, as corridors during dispersal.	
Riparian Zones				
Drainage Area	Characterised by *Eucalyptus xerothermica* and *Corymbia hamersleyana* woodland over broad-leafed *Acacia* shrubland on sandy loam soils, sometimes with exposed rocky areas. This habitat type can have high vegetation density, complexity and diversity; and it tends to occur on accretional or depositional areas and often has deeper and richer soils than	• This habitat is located in most of BHP Billiton Iron Ore's leases, in particular around Mining Area C, Mt Whaleback and Jimblebar. • A common habitat in central, south, and eastern parts of the Pilbara. • Occurs within national parks in the Pilbara.	•Rainbow bee-eater.	• Pilbara olive python; • Northern quoll; • Pilbara leaf-nosed bat; • Rainbow bee-eater; • Cattle egret; • Eastern great egret; • Grey falcon (*Falco hypoleucos*) – WC Act Schedule 3; IUCN Vulnerable; • Peregrine falcon (*Falco peregrinus*) – WC Act Schedule 7;

Fauna Habitat	Habitat Characteristics	Occurrence	Examples of Conservation-significant Species Habitat Use	
			Breeding	Foraging
	other fauna habitats. Grasses tend to be dominated by tussock grasses or the introduced buffel grass.			• Pilbara barking gecko; • Northern brushtail possum.
			A fairly diverse floristic assemblage provides habitat for a number of significant species. These species are not restricted to this habitat type.	
Drainage Line	Drainage Lines are low-lying, linear, gently sloping areas. They differ from the Major Drainage Line habitat by the absence of *Eucalypt* woodlands and from the Minor Drainage Line as they are not associated with ridgelines and hills.	• This habitat occurs mostly in the northern Pilbara and transects BHP Billiton Iron Ore's mainline rail in multiple locations. • A common habitat in the Pilbara occurring mostly in the north throughout the Chichester subregion. • Occurs within national parks in the Pilbara.	• Rainbow bee-eater.	• Pilbara olive python; • Northern quoll; • Pilbara leaf-nosed bat; • Rainbow bee-eater; • Cattle egret; • Eastern great egret; • Grey falcon; • Peregrine falcon; • Northern brushtail possum.
			Provides habitat for a number of significant species and aids in dispersal by providing a protected habitat. These species are not restricted to this habitat type.	
Fortescue Marsh samphire	Samphire is generally considered a hostile environment with extreme heat and salinity and generally occurs in waterlogged soils. The vegetation consists of members of the family Chenopodiaceae.	• Occurs in a single area on BHP Billiton Iron Ore's mainline rail where it passes through the Fortescue Marsh. • An uncommon habitat in the Pilbara but is fairly extensive around the Fortescue Marsh. • Not represented within national parks in the Pilbara.	• Spotted ctenotus; • Night parrot.	• Spotted ctenotus; • Night parrot.
			Many migratory bird species may occur in this habitat type after heavy rains. Spotted ctenotus (*Ctenotus uber johnstonei*) may also occur. The night parrot has been recorded north of Fortescue Marsh in similar samphire habitat.	
Major Drainage	The Major Drainage Line habitat comprises woodlands of large river red	• This habitat occurs in most of BHP Billiton Iron Ore's leases; however, the presence of silver cadjeput is uncommon and	• Pilbara olive python; • Northern quoll; • Rainbow bee-eater;	• Pilbara olive python; • Northern quoll; • Pilbara leaf-nosed bat;

<table>
<tr><th rowspan="2">Fauna Habitat</th><th rowspan="2">Habitat Characteristics</th><th rowspan="2">Occurrence</th><th colspan="2">Examples of Conservation-significant Species Habitat Use</th></tr>
<tr><th>Breeding</th><th>Foraging</th></tr>
<tr><td rowspan="2">Line</td><td rowspan="2">gums (Eucalyptus camaldulensis), coolibahs (E. victrix) and stands of silver cadjeput (Melaleuca argentea) over river pools. Open, sandy or gravelly riverbeds characterise this habitat type. In ungrazed areas, the vegetation adjacent to the main channel or channels is denser, taller and more diverse than vegetation on adjacent terrain and can include reedbeds around pools.</td><td rowspan="2">dependent on a shallow water table (e.g. near Weeli Wolli Spring).
• It is a widespread habitat throughout the Pilbara and is generally associated with the major rivers, such as the Fortescue, De Grey, Yule and Turner Rivers. Due to its linear nature only comprises a small proportion of the landscape.
• Occurs within national parks in the Pilbara.</td><td>• Grey falcon;
• Peregrine falcon;
• Northern brushtail possum.</td><td>• Rainbow bee-eater;
• Cattle egret;
• Eastern great egret;
• Grey falcon;
• Peregrine falcon;
• Northern brushtail possum.</td></tr>
<tr><td colspan="2">Major Drainage Lines represent an area of high local abundance and diversity for birds and may provide breeding (the taller trees and the tree hollows favour nesting habitats) and foraging habitat for several EPBC Act–listed conservation-significant species. Many species use them as corridors during dispersal. River pools within Major Drainage Lines may also attract EPBC Act–listed migratory birds.</td></tr>
<tr><td colspan="5">Disturbed/Cleared Areas</td></tr>
<tr><td rowspan="2">Artificial Habitats</td><td rowspan="2">Artificial habitats are habitats that have been altered by human activity.
Within the habitat mapping, these areas are called ‘Cleared’ and ‘Artificial Northern Quoll Habitat’. The latter areas are known to support northern quoll.</td><td rowspan="2">• Camps are scattered throughout the Pilbara, and rail and roads dissect much of the Pilbara. Other types of disturbance are common in the Pilbara but comprise a very small proportion of the entire Pilbara.</td><td>• Ghost bat
• Pilbara leaf-nosed bat
• Northern quoll</td><td>• Ghost bat
• Pilbara olive python</td></tr>
<tr><td colspan="2">Abandoned mines and adits are used as breeding roosts by both the Pilbara leaf-nosed bat and ghost bat. Ghost bats may use infrastructure (e.g. culverts) when feeding. Northern quolls are known to den in infrastructure, e.g. buildings, sleeper stockpiles, or abandoned quarries.</td></tr>
</table>

Source: Modified from Biologic (2014); updates made to conservation significant species following revision of conservation significant species listings in November 2015.

Permanent water bodies (pools and waterholes) within the Pilbara act as important refuges for aquatic biota (including fish, turtles, frogs and macroinvertebrates) during the dry season (Halse et al. 2002). The fish fauna of the Pilbara is characterised by low species diversity yet high levels of endemicity; over 42% of species recorded are restricted to the region (Unmack 2001; Allen et al. 2002).Lower reaches and the permanent and semi-permanent clear pools of the larger creek and river systems tend to support a larger diversity of species. Upper catchments were more likely to have physical impediments to dispersal resulting in fewer species (Streamtec 2002). Though diversity is low in these areas, abundance can often be high, particularly in response to climatic events.

Conservation-significant Vertebrate Fauna

An analysis of conservation-significant fauna records was undertaken in February 2016 to determine conservation-significant species that have been recorded from within the Project Definition Boundary (BHP Billiton Iron Ore 2016; see Appendix 4). Details of the data analysis that was undertaken for this project is provided in Appendix 4.

Fifty conservation significant species were identified from the Project Definition Boundary. These species, along with their associated Tier (see Table 7) and conservation status are listed in Table 22 below. (Note that for the purposes of this document, the Fortescue Grunter (a fish) has been included in the terrestrial fauna section.) Sixteen species were identified to be of higher conservation concern because more than 5% of their known Australian records occur within the Project Definition Boundary. Detailed information on these species is provided in Table 23.

Table 22: Conservation-significant species recorded from the Project Definition Boundary

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	WC ACT	DPAW	IUCN
TIER 1					
Curlew sandpiper	*Calidris ferruginea*	Critically Endangered/ Migratory/Marine	Schedules 3 & 5	n/a	Least Concern
Northern quoll	*Dasyurus hallucatus*	Endangered	Schedule 2	n/a	Endangered
Night parrot	*Pezoporus occidentalis*	Endangered	Schedule 1	n/a	Endangered
Australian painted snipe	*Rostratula benghalensis australis*	Endangered	Schedule 2	n/a	Endangered
Pilbara olive python	*Liasis olivaceus barroni*	Vulnerable	Schedule 3	n/a	n/a
Greater bilby or dalgyte or ninu	*Macrotis lagotis*	Vulnerable	Schedule 3	n/a	Vulnerable
Black-flanked rock-wallaby	*Petrogale lateralis lateralis*	Vulnerable	Schedule 2	n/a	Near Threatened
Princess parrot	*Polytelis alexandrae*	Vulnerable	n/a	Priority 4	Near Threatened
Pilbara leaf-nosed bat	*Rhinonicteris aurantia*	Vulnerable	Schedule 3	n/a	Least Concern
Grey falcon	*Falco hypoleucos*	n/a	Schedule 3	n/a	Vulnerable

Common Name	Scientific Name	EPBC Act	WC Act	DPaW	IUCN
Ghost bat	*Macroderma gigas*	n/a*	Schedule 3	NA	Vulnerable
Northern brushtail possum	*Trichosurus vulpecula arnhemensis*	n/a	Schedule 3	n/a	n/a
Peregrine falcon	*Falco peregrinus*	n/a	Schedule 7	n/a	Least Concern
TIER 2					
Pilbara flat-headed blind snake	*Anilios ganei*	n/a	n/a	Priority 1	n/a
Black-lined ctenotus or pin-striped fine-snout skink	*Ctenotus nigrilineatus*	n/a	n/a	Priority 1	n/a
Northern coastal free-tailed bat	*Ozimops cobourgianus*	n/a	n/a	Priority 1	Least Concern
Spotted ctenotus	*Ctenotus uber johnstonei*	n/a	n/a	Priority 2	n/a
Pilbara barking gecko	*Underwoodisaurus seorsus*	n/a	n/a	Priority 2	n/a
Spectacled hare-wallaby	*Lagorchestes conspicillatus leichardti*	n/a	n/a	Priority 3	n/a
Brush-tailed mulgara or ampurta	*Dasycercus blythi*	n/a	n/a	Priority 4	n/a
Letter-winged kite	*Elanus scriptus*	n/a	n/a	Priority 4	Least Concern
Short-tailed mouse	*Leggadina lakedownensis*	n/a	n/a	Priority 4	Near Threatened
Fortescue grunter	*Leiopotherapon aheneus*	n/a	n/a	Priority 4	Least Concern
Lined soil-crevice skink	*Notoscincus butleri*	n/a	n/a	Priority 4	Near Threatened
Western pebble-mound mouse or ngadji	*Pseudomys chapmani*	n/a	n/a	Priority 4	n/a
Long-tailed dunnart	*Sminthopsis longicaudata*	n/a	n/a	Priority 4	Least Concern
Garganey	*Anas querquedula*	Migratory/Marine	Schedule 5	n/a	Least Concern
Fork-tailed Swift	*Apus pacificus*	Migratory/Marine	Schedule 5	n/a	Least Concern

Common Name	Scientific Name	EPBC Act	WC Act	DPaW	IUCN
Cattle egret	*Ardea ibis*	Migratory/Marine	Schedule 5	n/a	Least Concern
Eastern great egret	*Ardea modesta*	Migratory/Marine	Schedule 5	n/a	Least Concern
Sharp-tailed sandpiper	*Calidris acuminata*	Migratory/Marine	Schedule 5	n/a	Least Concern
Pectoral sandpiper	*Calidris melanotos*	Migratory/Marine	Schedule 5	n/a	Least Concern
Red-necked stint	*Calidris ruficollis*	Migratory/Marine	Schedule 5	n/a	Least Concern
Long-toed stint	*Calidris subminuta*	Migratory/Marine	Schedule 5	n/a	Least Concern
Little ringed plover	*Charadrius dubius*	Migratory/Marine	Schedule 5	n/a	Least Concern
Oriental plover	*Charadrius veredus*	Migratory/Marine	Schedule 5	n/a	Least Concern
Gull-billed tern	*Gelochelidon nilotica*	Migratory/Marine	Schedule 5	n/a	Least Concern
Oriental pratincole	*Glareola maldivarum*	Migratory/Marine	Schedule 5	n/a	Least Concern
Barn swallow	*Hirundo rustica*	Migratory/Marine	Schedule 5	n/a	Least Concern
Black-tailed godwit	*Limosa limosa*	Migratory/Marine	Schedule 5	n/a	Least Concern
Rainbow bee-eater	*Merops ornatus*	Migratory/Marine	Schedule 5	n/a	Near Threatened
Eastern osprey or osprey	*Pandion haliaetus*	Migratory/Marine	Schedule 5	n/a	Least Concern
Ruff	*Philomachus pugnax*	Migratory/Marine	Schedule 5	n/a	Least Concern
Glossy ibis	*Plegadis falcinellus*	Migratory/Marine	Schedule 5	n/a	Least Concern
Little tern	*Sternula albifrons*	Migratory/Marine	Schedule 5	n/a	Least Concern
Wood sandpiper	*Tringa glareola*	Migratory/Marine	Schedule 5	n/a	Least Concern
Common sandpiper	*Tringa hypoleucos*	Migratory/Marine	Schedule 5	n/a	Least Concern

COMMON NAME	SCIENTIFIC NAME	EPBC ACT	WC ACT	DPAW	IUCN
Common greenshank or greenshank	*Tringa nebularia*	Migratory/Marine	Schedule 5	n/a	Least Concern
Marsh sandpiper	*Tringa stagnatilis*	Migratory/Marine	Schedule 5	n/a	Least Concern
Common redshank	*Tringa totanus*	Migratory/Marine	Schedule 5	n/a	Least Concern

Source: Adapted from DPaW (2015c).
* Note that the ghost bat is currently under consideration for listing under the EPBC Act (DotE 2015b).

Table 23: Details of conservation significant vertebrate fauna species for which more than 5% of known records, or those which are considered at higher risk of impact, occur within the Project Definition Boundary

SPECIES & CONS. STATUS	SPECIES DESCRIPTION	DISTRIBUTION	SPECIES ECOLOGY
TIER 1			
Northern quoll (*Dasyurus hallucatus*) EPBC Act: Endangered, WC Act: Schedule 2 Endangered; IUCN Endangered.	The northern quoll is the smallest and most arboreal of the four Australian quoll species and is brown with white spots on its back, rump and head and has a pointy snout (van Dyck & Strahan 2008).	The northern quoll has undergone a range contraction since European settlement, including a 75 % reduction in distribution during the 20th century. In the Pilbara, the northern quoll's distribution is bounded in the north, east and south by the Great Sandy Desert, Gibson Desert and Little Sandy Deserts (DotE 2014d).	The northern quoll occupies a diverse range of habitats (DotE 2016a); however within the Pilbara, it shows a close association with rocky habitats such as ironstone ridges, basalt mesas, granite outcrops and gorges (Begg 1981). They are primarily carnivorous, but will also opportunistically eat eggs or fleshy fruit (Oakwood 2002; Radford 2012). It is the largest animal in the world to undergo semelparity, whereby males experience immune system collapse and eventual death after an intense mating period (Oakwood et al. 2001); however this appears to be incomplete in the Pilbara. There are other notable differences in species ecology between those in the Pilbara and Northern Territory, with quolls in the Pilbara breeding later and for longer (Dunlop et al. 2012), and having more varied home ranges (King 1989; Oakwood 2002). Recent genetic studies suggest that Pilbara quolls are distinct from those in the Kimberley and Northern Territory, and there is sex biased dispersal with females showing stronger philopatric behaviour than males (Dunlop et al. 2015).
Pilbara olive python (*Liasis olivaceus barroni*) EPBC Act: Vulnerable, WC Act: Schedule 3	The Pilbara olive python is a large dark olive, yellowish brown to olive brown python with white to cream ventral surfaces (Swan & Wilson	The Pilbara olive python is described by the DotE (2014b) as being restricted to ranges within the Pilbara region; although an apparently isolated population occurs south on Mount Augustus in the Gascoyne region (Bush & Maryan 2011) and	During warmer months Pilbara olive pythons show a preference for riparian habitats (Doughty et al. 2011), and it uses waterholes in rivers and gorges to ambush prey that come in to drink (Pearson 2003). During the cooler months they use rocky habitats

Species & Cons. Status	Species description	Distribution	Species Ecology
Vulnerable	2010). The species can grow to 4.5 m in length, but is more commonly encountered at 2.5 m (Pearson 2003).	additional records exist in the north-eastern Carnarvon region. Within the Pilbara region, the species has been recorded from the Hamersley Range, Dampier Archipelago, Pannawonica, Millstream, Tom Price, Burrup Peninsula, and 70 km east of Port Hedland (DotE 2014b); the species is also known from riparian areas along the Fortescue drainage (Doughty et al. 2011).	such as escarpments, mesas, overburden heaps, and caves and gorges (Doughty et al. 2011). It has home range between 85 and 450 hectares (DoE 2014b) and moves around frequently within this range (Pearson 2003). Males can travel up to four kilometres during the mating season in search of females, returning to their home ranges in October (Pearson 2003). Breeding occurs between June and August, with the females laying eggs in October under large slabs of rock well away from water (Pearson 2003). The eggs hatch in January.
Greater bilby (*Macrotis lagotis*) EPBC Act: Vulnerable, WC Act: Schedule 3 Vulnerable; IUCN Vulnerable	The greater bilby is a small nocturnal burrowing marsupial that is restricted to the arid regions of central Australia. The greater bilby is rabbit-sized with large ears, a long pointed snout and a black tail with a white tip. It has long, grey fur over most of the body and white to cream on the belly (van Dyck & Strahan 2008).	In the Pilbara bioregion the greater bilby exists along the Fortescue River and north-east to Shay Gap (DotE 2014a). The extent of occurrence for the greater bilby is thought to have remained relatively stable over the last 20 years. However, given the remote distribution of this species it is likely that the current distribution is inadequately mapped (DotE 2014a). Within the Pilbara region, most records come from the eastern half of the region, although there are a small number of records in the western and northern parts.	The Greater Bilby occurs in a variety of habitats, usually on landforms with level to low slopes and light to medium soils (DotE 2014a); however it is generally restricted to those areas that contain suitable burrowing habitat, e.g. sandy and alluvial soils. It is a mostly solitary animal (Sustainable Consulting 2013), and is highly mobile with a large foraging range; the home range for females is around 18 hectares and males is approximately 320 hectares. It digs burrows 2 m to 3 m deep that are primarily used for shelter during the day time. An individual may have over a dozen burrows within its home range. The greater bilby has a varied diet comprising seeds, bulbs and invertebrates (Moseby & O’Donnell 2003). Breeding can occur throughout the year, with females producing up to four litters a year.

Species & Cons. Status	Species description	Distribution	Species Ecology
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) EPBC Act: Vulnerable, WC Act: Schedule 3 Vulnerable	The Pilbara leaf-nosed bat is a moderate-sized bat with relatively small ears and a fleshy nose-leaf structure surrounding the nostrils. The fur is most often bright orange, and wings dark brown, but brown, yellow, and white individuals are also known (Churchill 2008); paler bats are likely to be older. The species differs from other members of its family in having an elaborate, rounded and scalloped nose-leaf.	The Pilbara leaf-nosed bat occurs over an approximate area of 120 million ha and is restricted to the Pilbara and northern parts of the Gascoyne regions of Western Australia (DotE 2014c). Armstrong (2001) suggests that there may be three discrete sub-populations – the eastern Pilbara, Hamersley Range and upper Gascoyne, which are separated by extensive flat areas restricting gene flow.	The Pilbara leaf-nosed bat is a poor thermoregulatory, and therefore has an obligate reliance on hot humid caves and mines (generally ranging between 28 and 32 ºC and 96-100 % humidity) to prevent evaporative water loss (Churchill 2008). It uses three types of roosts; maternity, day and night, with the latter two used to expand its foraging range. It can forage in any habitat where insect biomass is sufficiently high (McKenzie & Bullen 2013); however it is thought to prefer *Triodia* hummock grasslands on hills and shallow gullies, and creeks containing river red gum (*Eucalyptus camaldulensis*) (Churchill et al. 1998). An individual's home range is likely limited by roosting sites, but it is thought that they can move up to 10 km from roosting sites when foraging (DotE 2016b). Breeding occurs in July, with females giving birth in December and January (Churchill 2008). Genetic studies show that females show high site fidelity, with male mediated gene flow (Molhar 2011). Population estimates are difficult to determine; however a number of significant roosts have been located in the western (API 2015), eastern (Rio Tinto 2013) and northern Pilbara (DotE 2014c).
Ghost bat (*Macroderma gigas*) WC Act: Schedule 3 Vulnerable; IUCN Vulnerable	The ghost bat is the largest micro-bat in Australia and the second largest in the world. It has light-coloured fur and extremely thin light-coloured wing membranes. Populations	Ghost bats occur across most of northern Australia; however the relatively recent contraction of the distribution in central Australia has left the Pilbara population of ghost bats isolated by extensive sandy deserts (Worthington-Wilmer et al. 1994). Worthington-Wilmer (2012) considers that only 14	Ghost bats forage in a wide range of habitats, but are more specific with their roost sites. Abandoned horizontal mine tunnels comprise a significant portion of the known ghost bat roost sites (Woinarski et al. 2014). Ghost bats are Australia's only carnivorous bat. They are active at night, hunting prey such as

SPECIES & CONS. STATUS	SPECIES DESCRIPTION	DISTRIBUTION	SPECIES ECOLOGY
	close to the coast tend to have pale grey or light brown coats, while populations further inland appear almost white. Ghost bats have relatively large eyes, no tail, and a long simple nose-leaf. (DotE 2015b).	maternity roosts are known in Australia.	small mammals, birds, lizards, frogs and sometimes large insects. Prey is detected by using echolocation, vision, or hearing. To hunt, the ghost bat perches on a branch, rocky overhang, or small cave and waits to ambush prey (DotE 2015b). Ghost bats disperse widely when not breeding, but concentrate around maternity roosts in July and August when mating takes place. Births occur in September and October, the young begin to fly at 7 weeks, and are completely weaned by the March following their birth. A recent population estimate has been given as less than 10,000 individuals (Woinarski et al. 2014), with the Pilbara population comprising between 1,800 and 2,400 individuals (Biologic and Bat Call WA 2014).
TIER 2			
Pilbara flat-headed blindsnake (*Anilios ganei*) DPaW Priority 1	The Pilbara flat-headed blindsnake is a small, light grey to light brown wormlike snake. The largest specimens' measure up to 300 mm long from snout to vent (Aplin 1998). As the name suggests, the head is slightly dorsoventrally flattened.	The Pilbara flat-headed blindsnake is endemic to the Pilbara region and only recorded from a few specimens. Previous studies have recorded this species on alluvial floodplains (Biologic 2015).	As this species lives underground, the Pilbara flat-headed blindsnake is rarely encountered in field surveys and little is known of this species' ecology. Similar to most other blindsnakes, it is insectivorous, feeding on termites and their eggs, and larvae and pupae of ants (Wilson & Swan 2010). They are thought to be oviparous (egg-laying) although this has only been observed in a few species of blindsnakes. The Pilbara flat-headed blindsnake is associated with moist gorges and gullies (Wilson & Swan 2010), and potentially with a wide range of other stony habitats. Based on the likely habitat characteristics and the occurrence of previous records, the species' is considered to potentially occur within gorge/gully, minor drainage line, major

Species & Cons. Status	Species description	Distribution	Species Ecology
			drainage line, mulga woodland, and floodplain habitats (Biologic 2015).
Black-lined ctenotus (*Ctenotus nigrilineatus*) DPaW Priority 1	A relatively small *Ctenotus* skink, with a pale head with black markings, and a black back and sides with eight white stripes.	A Pilbara endemic, from which most records are from the Chichester subregion; although there is an isolated record from the vicinity of Tom Price.	Little is known about the ecology of this species. Available information suggests that it is only known from spinifex at the base of granite outcrops (Wilson & Swan 2010).
Spotted ctenotus (*Ctenotus uber johnstonei*) DPaW Priority 2	*Ctenotus uber johnstonei* is a small ctenotus skink that differs from other subspecies of *C. uber* in that the nasal cavities are adjoining (Storr 1980). It is predominantly reddish with an olive tinge to the tail, compared to other species which are olive coloured throughout. A narrow black stripe runs from the neck to the base of the tail, while reddish/whitish spots dot the sides. It has a snout to vent length of up to 70 mm (Storr 1980).	The subspecies johnstonei was first described in 1980 (Storr 1980) from Balgo Hill in the far north east of Western Australia. Specimens occurring in the Pilbara may be grouped with *Ctenotus uber johnstonei*, or they may belong to an undescribed taxon, in which case they would have no official conservation status. As a precautionary approach, the Pilbara taxon is treated as the Priority 2 subspecies (DPaW 2015b).	Little is known of this taxon, and its taxonomic status is uncertain. Most *Ctenotus* skinks are highly active, foraging among a diverse range of habitat. Habitat for this subspecies is mapped as Stony Plain and Mulga. Individuals have been recorded from *Triodia* growing on hillslopes, and *Acacia xiphophylla* scattered tall shrubs to high open shrubland over *Sclerolaena cuneata* herbland (Environ Australia 2004). Studies of other species of *Ctenotus* skinks reveal a lifespan of between four to seven years, with two eggs typically laid by each species in early summer (Read 1998). Most species occupy home ranges, with a maximum recapture radius of around 50 metres. Prey is primarily insects, termites, and spiders, although sometimes plant material is also ingested (Read 1998).
Pilbara barking gecko (*Underwoodisaurus seorsus*) DPaW Priority 2	The Pilbara barking gecko is a recently described species (Doughty & Oliver 2011), with Pilbara records previously being attributed to	It is restricted to rocky ranges of the Hamersley Range, primarily within the vicinity of Karijini National Park. As of December 2015, Naturemap lists 14 records for the Pilbara barking gecko located to the north-east and south-west of Karijini National Park.	This species hasn't been well studied, but observations from records suggest that it is restricted to rocky areas within the Hamersley Range, where it has been observed sheltering under a rock slab (Menz & Cullen 2006) and at the bottom of a rocky

Species & Cons. Status	**Species description**	**Distribution**	**Species Ecology**
	Underwoodisaurus milii which occurs from Shark Bay WA across to South Australia. It is a moderately large species of gecko measuring up to 100 mm snout-vent length, with a large head, long slender limbs and digits, and a pointy tail (Doughty & Oliver 2011).	There are a further 13 records of *U. milii* from the Pilbara which almost certainly records of the Pilbara barking gecko.	gorge with low tree cover (Thomson et al. 2009). It has been recorded a number of times within the vicinity of BHP Billiton Iron Ore's Mining Area C operations, where the vegetation has been described as scattered snappy gum (*Eucalyptus leucophloia*) over low *Acacia* shrubs and *Triodia* hummock grasslands. Recent observations have been made of this species sheltering in caves (M. O'Connell, Biologic, pers. comm., Nov 2015).
Spectacled hare-wallaby (*Lagorchestes conspicillatus leichardti*) DPaW Priority 3	The spectacled hare-wallaby is a large stocky marsupial with distinctive bright orange rings around its eyes. The fur is brown on the back and white on the underbelly. They can grow up to 470 mm long and weigh up to 4.5 kg, while the sparsely-haired tail can be up to 490mm long (Strahan 1998). There are two subspecies, *L. conspicillatus conspicillatus* only occurs on Barrow Island and the second (*L. conspicillatus leichardti*) occurs on the mainland.	Formerly, the spectacled hare-wallaby (mainland) occupied nearly all of the northern half the Australian continent. The current distribution is now very patchy. In Western Australia, it is rare and has been reduced to a few isolated populations in the Pilbara, the Kimberley and the far north-east of the Great Sandy Desert. In the Northern Territory it is widespread but patchy, and in Queensland it is widespread but uncommon (Woinarski et al. 2014).	The spectacled hare wallaby occurs in a range of grassland and woodland habitats. On Barrow Island and in the Pilbara, the species shelters inside large spinifex hummocks during the day to keep cool. They emerge around late dusk to graze on spinifex, herbs and shrubs. The average lifespan of a spectacled hare-wallaby is approximately six years. Sexual maturity is reached at about one year and breeding takes place throughout the year (Woinarski et al. 2014). The species is generally solitary, though small groups of up to three individuals have been seen grazing together (Strahan 1998).
Brush-tailed mulgara (*Dasycercus blythi*) DPaW Priority 4	The brush-tailed mulgara is a large carnivorous marsupial weighing approximately 100 grams, with a body length of	The brush-tailed mulgara has a wide distribution across central and inland Australia, bounded by the Tanami, Simpson and Great Victorian deserts in the north, east and south respectively, and by the Pilbara	This species is associated mostly with spinifex grasslands but can also forage around open sandplains, grasslands and woodlands if they are adjacent to spinifex habitat. It is primarily nocturnal

SPECIES & CONS. STATUS	SPECIES DESCRIPTION	DISTRIBUTION	SPECIES ECOLOGY
	150 mm and a tail length of 90 mm. Males are usually larger than females. The fur is a sandy yellowish colour on top and white on the belly, while the last fifth of the tail ends in coarse black fur (Woinarski et al. 2014). This species is most easily distinguished from the crest tailed mulgara (*D. cristicauda*) by the tip of the tail which forms a crest in *D. cristicauda,* but does not form a crest in *D. blythi.*	region in the west. Exact ranges are difficult to determine due to past nomenclature confusion with *D. cristicauda* and *D. hillieri*, which were synonymised and then subsequently split (Woinarski et al. 2014).	and feeds on a broad range of invertebrates as well as small vertebrates (Masters 1998). A study by Dickman (2006) revealed that the brush-tailed mulgara is a keystone predator, playing a critical role in maintaining the diversity of smaller mammal species. Typically a solitary animal, its home range varies from 2 to 25 ha, depending on the quality of habitat and abundance of food. Male home ranges are generally larger than those of females (Woinarski et al. 2014). Breeding occurs from June to November, and females give birth to a litter of approximately six. Young are weaned and independent by 10 months, and lifespan in the wild is between two to three years (Masters 1998).
Short-tailed mouse (*Leggadina lakedownensis*) DPaW Priority 4	The short-tailed mouse is one of two species of short-tailed mice endemic to Australia and weighs approximately 15 to 20g (Moro & Kutt 2014). The back is grey-brown to grey, while the underside is pure white. Adults in good condition may appear to be somewhat chubby. As the name suggests, the tail is noticeably short (shorter than the head-body length).	The short-tailed mouse occurs in a diverse range of environments, from semiarid climates to the monsoon tropical coasts. In the Pilbara, habitat includes spinifex and tussock grasslands, *Acacia* shrub-lands, sandy soils, cracking clays and stony ranges. (Moro & Kutt 2014). Long-term data suggests that populations fluctuate, decreasing during times of draught and increasing during times of rainfall and vegetation growth.	The short-tailed mouse is nocturnal and largely solitary, spending days in simple single-chambered burrows which provide shelter during the hot day-time temperatures (Moro & Kutt 2014). Tracking data shows that the mice use different burrows each night. Their diet consists primarily of invertebrates, but can be supplemented with plants to meet water requirements. The species' home ranges are approximately 5 hectares, and an individual may travel up to 600 metres from its burrow in one night. Reproduction tends to depend more on rainfall than the time of the year, as females have been recorded breeding throughout the year, but more often after heavy rainfall (Moro & Kutt 2014). A litter of about three or four are born after a gestation period of approximately 30 to 40 days, and young are fully weaned and independent by four weeks old (Moro &

SPECIES & CONS. STATUS	SPECIES DESCRIPTION	DISTRIBUTION	SPECIES ECOLOGY
			Kutt 2014).
Fortescue grunter (*Leiopotherapon aheneus*) DPaW Priority 4 IUCN Near Threatened	The Fortescue grunter is a small bronze to brownish inland fish. It has a paler belly than back, and irregular darker wavy lines run across the sides of the fish. The intensity of the coloration varies between drainage lines. Juveniles of this species have indistinct vertical bars (Gomon 2011).	The Fortescue grunter has a restricted distribution within the Pilbara and is only known from the Fortescue, Robe and Ashburton river systems (Allen et al. 2002). It is considered to be reasonably common within this range. In the Fortescue River system it has been recorded as far east as Fortescue Falls (WRM, unpub. data) and Fern Pool (Morgan & Gill 2004).	This species inhabits slow to fast flowing clear freshwater streams and pools over sandy and rocky bottoms (Gomon 2011). Little is known of the reproductive biology of the Fortescue grunter, but it is likely to produce demersal eggs (eggs which remain on the bottom of the streambed, either free or attached to the substrate). They are known to feed on small crustaceans and other small fishes.
Lined soil-crevice skink (*Notoscincus butleri*) DPaW Priority 4	The Lined soil-crevice skink is pale coppery brown with bold black vertebral and dorsal stripes, a broad black upper lateral stripe, a white mid-lateral stripe, and a narrow dark ventrolateral stripe. It has a snout-vent length of up to 42 mm (Wilson & Swan 2010).	Distribution of the lined soil-crevice skink is limited to the Pilbara bioregion of Western Australia, with one isolated record in the south-west of the Great Sandy Desert bioregion (DPaW 2016).	This species occurs in arid, rocky, near-coastal Pilbara habitats. It is associated with spinifex-dominated areas near creeks and river margins (Wilson & Swan 2010).
Western pebble-mound mouse (*Pseudomys chapmani*) DPaW Priority 4	The western pebble-mount mouse is a small brownish mouse, weighing approximately 10 to 15 grams. It has a medium to long, pinkish brownish tail and a white belly. They are	The western pebble-mound mouse is now considered endemic to the Pilbara after experiencing a significant decline in range throughout the Gascoyne and Murchison regions (van Dyck & Strahan 2008). Mounds of the western pebble-mound mouse are common but sparsely distributed within their abundant	This species nests almost exclusively on the gentler slopes of hills and ranges where the ground is covered with small stones and gravel. The preferred vegetation is typically *Triodia* grassland with occasional *Eucalyptus* trees or *Acacia* (van Dyck & Strahan 2008). Animals live in small family groups below mounds of pebbles which are constructed and

SPECIES & CONS. STATUS	SPECIES DESCRIPTION	DISTRIBUTION	SPECIES ECOLOGY
	morphologically distinguishable from other pebble-mound mice (Woinarski et al. 2014).	habitat.	constantly tended. Mounds may cover an area of up to 10 square metres and include up to fourteen individual animals. Each pebble in the mound can weigh up to 10 grams (the weight of a mouse) but are around 3 grams on average (Woinarski et al. 2014). Females can produce several litters of up to four young each year (IUCN 2015). Males may disperse long distances, but females only disperse to neighbouring mounds.
Long-tailed dunnart (*Sminthopsis longicaudata*) – DPaW Priority 4	The long-tailed dunnart is a relatively large dunnart, weighing up to 25 g, and measuring up to 320 mm (tail length comprising over two-thirds of this) (Burbidge et al. 2008). The back is grey, and the underside is pale cream to white. It is easily distinguished from other species of dunnart by the tail length.	The long-tailed dunnart has been recorded widely in the arid zone between the Pilbara and Murchison regions in the west across to the southern-central desert regions of the Northern Territory (Burbidge et al. 2008). It is considered rare and scattered within its range, but can be locally common (e.g. Jack Hills in the Murchison region; Ecologia Environment 2008)	Long-tailed dunnarts are mostly found in rocky country in the western arid zone, although occasionally individuals have been recorded in open country with a gravel/stony mantle. It feeds mostly on invertebrates (arthropods), and fat can be stored at the base of its tail (Burbidge et al. 2008). Breeding appears to occur from August with young dispersing by March/April (Burbidge et al. 2008).

1. The crest-tailed mulgara (*Dasycercus cristicauda*) is not included in the table as it is not believed to occur in Western Australia. It is noted however that there are a number of records from the Pilbara region still within government databases.

2. Records of *Lerista macropisthopus remota* adjacent to BHP Billiton Iron Ore's Whaleback operations are incorrect. These are records of *Lerista neander.* Feedback was provided to Naturemap on these records in 2011. Their database is yet to be updated.

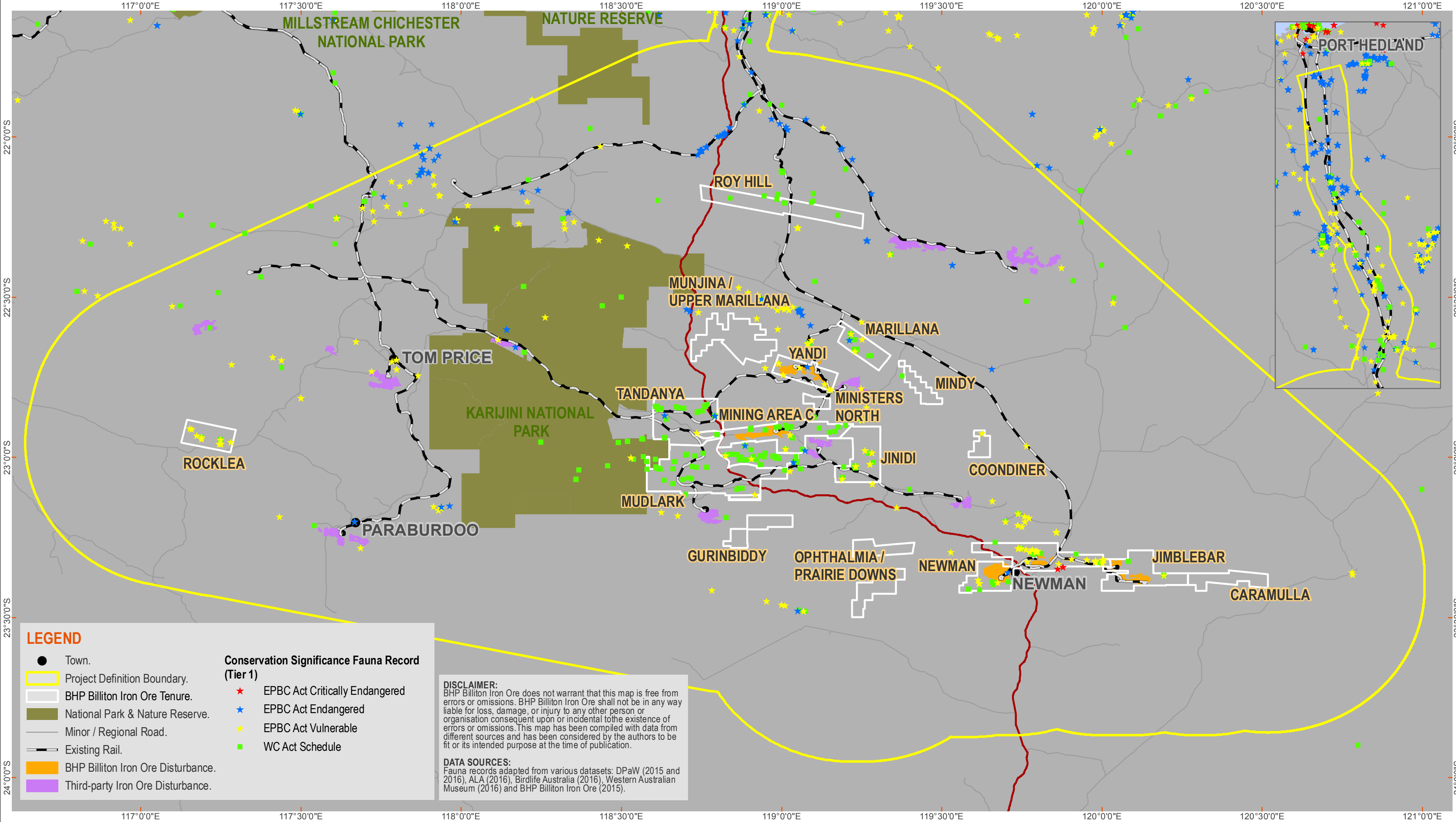

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Figure 30a Conservation-significant fauna records relative to the Project Definition Boundary (Tier 1 species)

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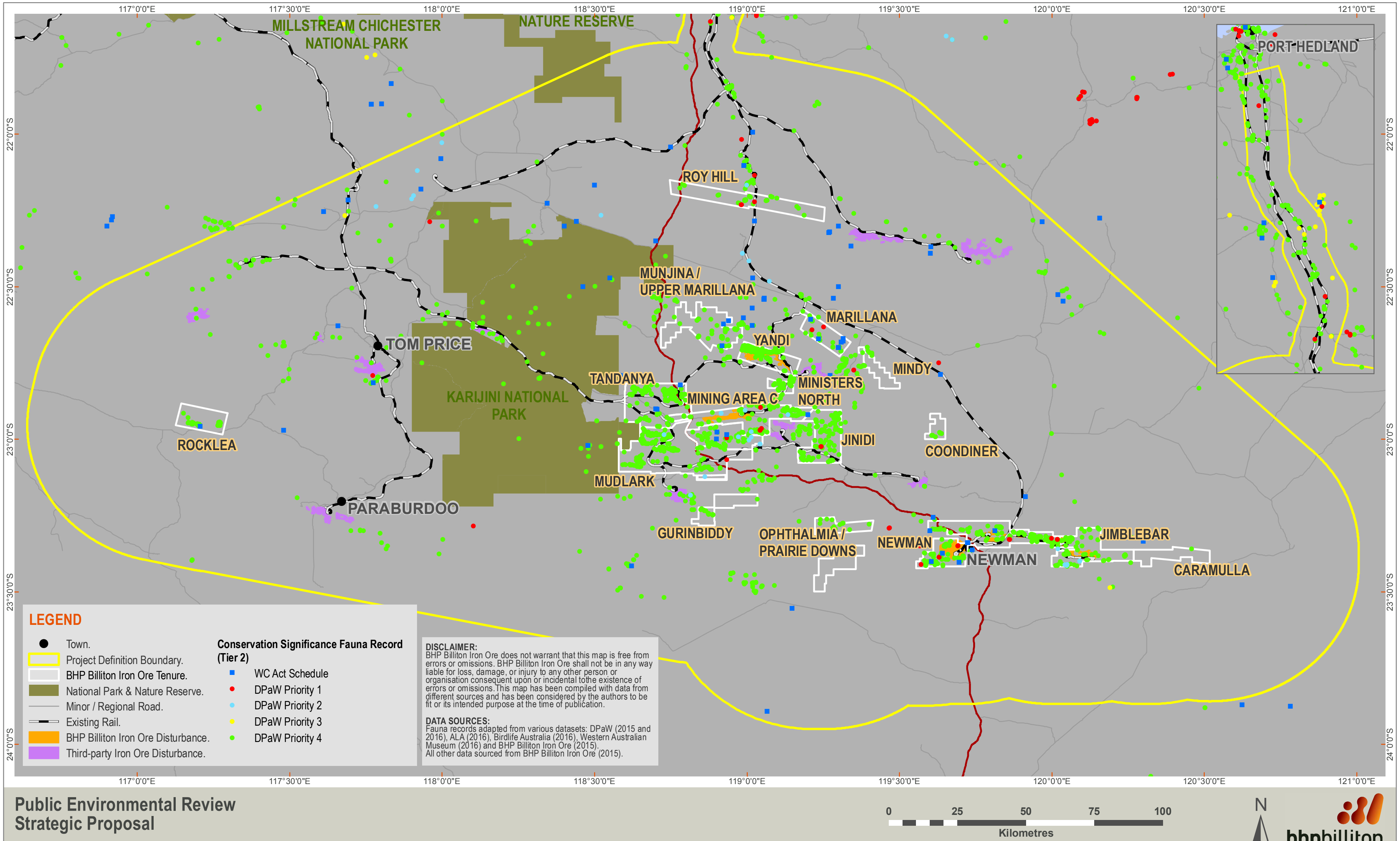

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Figure 30b Conservation-significant fauna records relative to the Project Definition Boundary (Tier 2 species)

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Short-range Endemic Fauna

Short-range endemics (SREs) are defined as terrestrial and freshwater invertebrates with naturally small distributions and which may inhabit discontinuous or fragmented habitats (EPA 2009). SRE fauna taxa typically display characteristic ecological and life-history traits, including (Harvey 2002):

- restricted ability to disperse;
- confinement to fragmented habitats;
- often highly seasonal activity patterns; and
- low reproductive capacity.

Short-range endemism is influenced by several factors including life history, physiology, habitat requirements, dispersal capabilities, biotic and abiotic interactions and historical conditions which, not only influence the distribution of a species, but also the tendency for differentiation and speciation (Ponder & Colgan 2002). In recent years a number of taxonomic groups of invertebrates have been highlighted as comprising a high proportion of species likely to be regarded as short-range endemics (SREs) (i.e. Harvey 2002; freshwater snails: Ponder & Colgan 2002; land snails: Johnson et al. 2004; mygalomorph spiders: Main et al. 2000).

Harvey (2002) proposed a range criterion for terrestrial short-range endemic (SRE) species at less than 10,000 km^2 (or 100 km x 100 km), which has been adopted by regulatory authorities in Western Australia (EPA 2009). SRE invertebrate species often share similar biological, behavioural and life history characteristics that influence their restricted distributions and limit their wider dispersal (Harvey 2002). For example, burrowing taxa such as mygalomorph spiders and Urodacus scorpions may only leave their burrows (or a narrow home territory around the burrow) as juveniles dispersing from the maternal burrow, or when males search for a mate. In other cases SRE taxa are dispersal-limited because of their slow pace of movement and cryptic habitats (such as isopods, millipedes and snails), while some specialised taxa can be limited by very specific habitat requirements, such as selenopid spiders within fractured rocky outcrops.

Currently within Western Australia there are seven taxonomic groups that are used to assess the impact of a disturbance on SRE invertebrate taxa and habitats; the groups are described briefly below.

Mygalomorph spiders (trapdoor spiders)

Mygalomorph spiders comprise trapdoor and funnel web spiders. A large proportion of mygalomorph spider species are unnamed (Main 2008). In arid and semi-arid areas, mygalomorph spiders dig deep burrows (up to 60 centimetres [cm] deep) (Simon-Brunet 1994) and exit burrows at night to feed when the temperature is lower and humidity is higher (Main 1982). Nest micro-climate (e.g. soil moisture and temperature) is an important factor in mygalomorph spider burrow suitability (Main 1982). Mygalomorph burrows in the Pilbara region are often found low in the landscape and associated with landform features such as colluvial flats, broad valleys, mulga woodlands or where pockets of deep soil accumulate.

Most mygalomorph spiders are sedentary and tend to live their entire lives within a single burrow (Main, 1982) although mature males abandon the burrow when finding a mate.

Selenopid spiders

Selenopids are extremely dorsoventrally flattened and superficially resemble huntsman spiders. Their flat body shape allows them to live in narrow crevices between rocks, under bark and in a variety of other microhabitats (Crews & Gillespie 2010). They are extremely fast, and are primarily found in the tropics and subtropics (Crews & Gillespie 2010). Selenopids can be broadly grouped into those that live in rocky habitats and those that live beneath bark. Those that inhabit isolated rocky outcrops are predisposed to having restricted ranges and are more likely to be SRE compared with the bark dwelling species that tend to exist in contiguous habitats (Biologic 2015).

Pseudoscorpions

Pseudoscorpions occur in leaf litter, under rocks and the bark of trees (Harvey & Yen 1989). Similar to scorpions, all pseudoscorpions are predators, feeding on small invertebrates (Harvey & Yen 1989) and are generally only active during the night or in dark places during the day. Pseudoscorpions are usually no more than several millimetres long and have a pair of pincer-like pedipalps which they use to subdue small invertebrate prey (Harvey & Yen 1989).

Harvey (2002) indicates that very few pseudoscorpions are SREs (after Harvey 1998). In some species of pseudoscorpion, it is common for individuals to cling to larger animals (usually insects), resulting in the pseudoscorpion being transported across larger distances (Harvey & Yen 1989).

Scorpions

Scorpions are found all over Australia, occurring under rocks and logs, and in burrows, while a few inhabit cracks and fissures within the bark of trees, especially eucalypts (Harvey and Yen 1989). Scorpions are predators and feed on beetles, millipedes and spiders, are generally only active during the night or in dark places during the day (Australian Museum 2008) and are typically solitary.

Millipedes

Harvey (2002) indicates that many millipedes from the Order Chordeumatida are SREs. Most millipedes are detritivores (Sierwald and Bond 2007), obtaining nutrients from consumption of decomposing organic matter. Millipedes are typically collected from mesic habitats and microhabitats and are commonly found among deep leaf litter and beneath rocks and bark in sheltered locations. Millipedes are susceptible to desiccation, movement is limited and they are unlikely to be transported by larger animals (Sierwald and Bond 2007).

Terrestrial snails

Harvey (2002) indicates that many snails of the Order Archaeogastropoda are SREs as well as numerous snails from the Orders Sorbeoconcha and Eupulmonata. Snails of the order Archaeogastropoda are herbivorous and can be found among thick leaf litter, rocks or in trees (Harvey and Yen 1989). The sexes are separate in the Order Archaeogastropoda (Harvey and Yen 1989).

Land snails prefer moist habitats, though some species of the Order Archaeogastropoda are found in areas that are only occasionally moist (Harvey and Yen 1989). Land snails require a source of calcium for shell construction, usually sourced from soil or rock (Slack-Smith 2002).

In drier areas snails may undergo an extended period of dormancy up to 50 cm below ground. Many terrestrial snails have extremely restricted ranges and numerous species are known to be SREs, indeed some families consist entirely of SRE species (EPA 2009; Harvey 2002).

Isopods

Slaters are terrestrial isopods that belong to the crustacean suborder Oniscoidea. They generally obtain nutrients from consumption of decomposing organic matter and usually do not exceed 15 mm in length. Slaters are found in tropical to arid climates, where they inhabit moist and sheltered locations such as those beneath rocks, logs and bark. Species diversity amongst slaters is strongly linked to leaf litter composition. Specialisation often occurs in microhabitats created by the mixing of leaf litter from different flora species (Wardle 2006). Slaters are likely to contain species which are SREs (EPA 2009).

Habitats with the potential to support SREs occur within all bioregions of Western Australia. In the Pilbara, these habitats are likely to be found associated with south-facing rock faces and steep slopes, deep gorges and springs, deep litter beds, rocky outcrops, and undisturbed watercourses or various combinations of these features (Main 1999; EPA 2009) which contribute to a greater moisture holding capacity than surrounding areas (Harvey 2002).

Such habitats may only support small, localised populations and may not consistently offer suitable microhabitats. Factors other than habitat can play a role in determining a species range and pattern of distribution (e.g. competition or prior occupancy).

BHP Billiton Iron Ore commissioned Biologic to assess impacts of the Strategic Proposal on SREs. The report provides a review of SRE species data as summarised below and provides an impact assessment focussing on SRE habitat suitability (see Appendix 5).

As of 30 May 2013, a total of 144 SRE or potential SRE species had been recorded (based on database searches) within an area encompassing 16,200,000 ha (referred to in this section as the 'Study Area' which corresponds largely to the Pilbara bioregion) (Appendix 5). This total comprised mygalomorph spiders (59 species), selenopid spiders (13 species), scorpions (10 species), pseudoscorpions (13 species), snails (4 species), millipedes (35 species), and isopods (10 species). Assessment of the regional distribution of species was not possible for all SRE faunal groups due to incomplete and patchy survey data; however, the spatial extent of survey work in the Pilbara and the consistent collection of particular faunal groups (namely Camaenid snails, *Urodacus* scorpions, *Antichiropus* millipedes, and Mygalomorph spiders) have provided some examples of regionalisation. Further, it is noted that invertebrate taxonomy for species groups considered to contain SRE taxa is highly dynamic, an assessment of SRE status changes continually as further survey and taxonomic work is undertaken.

Biologic (Appendix 5) conducted a review of SRE species recorded within BHP Billiton Iron Ore tenure and third party project areas as of September 2013. A total of 60 SRE species (490 records) had been recorded within the BHP Billiton Iron Ore tenure, compared to 13 SRE species (17 records) recorded within third party project areas as of this date. It was noted that this result was more likely to be an artefact of sampling intensity rather than a lower capacity of the third party project areas to support SRE fauna. None of the SRE species recorded in third party project areas were recorded within the BHP Billiton Iron Ore tenure.

The SRE habitat suitability assessment conducted by Biologic (Appendix 5) had two phases:

- Phase 1 - investigated land system suitability for SRE habitats, within the context of regional SRE fauna sampling effort and current knowledge of SRE fauna distribution patterns.
- Phase 2 - consolidated the Phase 1 assessment with regional vegetation mapping (Onshore 2014) and regional vertebrate fauna habitat mapping (Biologic 2014) so as to produce:
    - a detailed, consolidated map of the 'broad SRE habitat units' across BHP Billiton Iron Ore tenure;
    - an assessment of the suitability of the 'broad SRE habitat units' across BHP Billiton Iron Ore tenure; and
    - an assessment of the relative importance and proportional area of each broad SRE habitat unitacross BHP Billiton Iron Ore tenure, within each BHP Billiton Iron Ore tenement and with respect to the Full Conceptual Development Scenario disturbance footprints.

The Phase 1 work examined all 74 land systems that occur within the SRE 'Study Area' and assessed these for the presence of SRE habitat types, which were Deep Gullies and Gorges, Shallow Gullies, Ridges, Boulders, Breakaways, Outcrops, Isolated Sand, Groves, Drainage Foci, Swamps, Salt Lakes and Waterholes. These SRE habitat types were categorised through identifying the presence of microhabitats relevant to SRE fauna and the likelihood of SRE fauna occurring. The following microhabitat types were identified as being most important for the presence of SRE fauna in the Pilbara:

- leaf litter, including humus and organic topsoil;
- heavy vegetation, including bark, logs and debris;
- rocky microhabitats, cracked and loose rock material;
- deep soils, particularly non-skeletal; and
- microrelief; small, ground-level variations in elevation.

Each of the SRE habitat types comprise an assortment of microhabitat types described above, which influence the presence of SRE fauna. Habitat suitability was determined by assigning a likelihood (low/medium/high) of

SRE occurrence and frequency (low/medium/high) of SRE microhabitat occurrence within each SRE habitat type. This information, along with SRE diversity information, was used to derive overall habitat suitability for each land system (see Appendix 5 for further detail regarding methodology). Of the 74 land systems in the Study Area, 11 were regarded as having High SRE suitability, seven as having Medium/ High, 24 as having Medium, 18 as Low/ Medium and 13 as having Low SRE suitability. Below is a brief summary of each rating and the SRE habitat types they contain.

High (5) SRE suitability land systems

All but one High suitability land system was associated with Deep Gullies and Gorges.

Medium/ High (4) SRE suitability land systems

These land systems primarily comprise slope type habitats; Shallow Gullies, Ridges, Boulders and Outcrops, with some Groves, Drainage Foci and Isolated Sands.

Medium (3) SRE suitability land systems

These land systems have an even spread of most habitats, particularly Shallow Gullies, Ridges, Outcrops, Isolated Sands, Groves and Drainage Foci. The majority of the Swamp habitats are also in this category, along with the Salt lake habitat.

Low/ Medium (2) SRE suitability land systems

This category is dominated by land systems with Shallow Gullies, Outcrops, Groves and Drainage Foci in Low frequencies.

Low (1) SRE suitability land systems

There are no SRE habitats expected in these land systems, but more than half still contained SRE dispersal habitats.

Phase 2 of the SRE habitat suitability assessment involved producing a tenure-scale assessment of habitat suitability at higher resolution than the Phase 1 work. Phase 2 involved supplementing the Phase 1 results using data consolidated across BHP Billiton Iron Ore’s tenure for terrestrial vertebrate fauna habitat mapping (Biologic 2014, described earlier within this section) and flora and vegetation mapping (Onshore 2014, described in Section 8.1.3).

Each of the 17 vertebrate fauna habitats (Biologic 2014) were investigated for their suitability for SRE habitat types. Of the 17 vertebrate fauna habitats, eight were regarded as likely to contain SRE habitats, one likely to contain SRE dispersal habitats and eight regarded as unlikely to contain habitats suitable for SRE fauna (Table 4.9). Artificial / disturbed habitat was also considered to have no SRE habitat value.

Onshore (2014) classified the vegetation data into 16 landforms, which were broadly congruent with vertebrate fauna habitats from Biologic (2014). Through this broad connection, the Onshore landforms were categorised with respect to their suitability for SRE habitats. These landforms identified by Onshore (2014) were then examined to identify which of the landforms contained vegetation associations likely to be suitable for SRE fauna.

The above mapping data were compiled into a single dataset and reclassified according to the SRE habitat types (defined in Phase 1), creating 10 broad SRE habitat units based on similar landform, drainage and vegetation characteristics. Each of the broad SRE habitat units features a varying number of potential SRE habitat types that are all related to the range of habitat characteristics found within the broader unit (for example, within the Boulders, Outcrops, Ridges and Breakaways habitat unit, there would be expected to be a number of potential SRE habitats such as boulder piles, ridges, breakaways and rocky outcrops). Each of these landform units are detailed in Appendix 5.

The SRE suitability mapping from Phase 1 (broad Pilbara Study Area) and Phase 2 (BHP Billiton Iron Ore tenure) is shown in Figure 31.

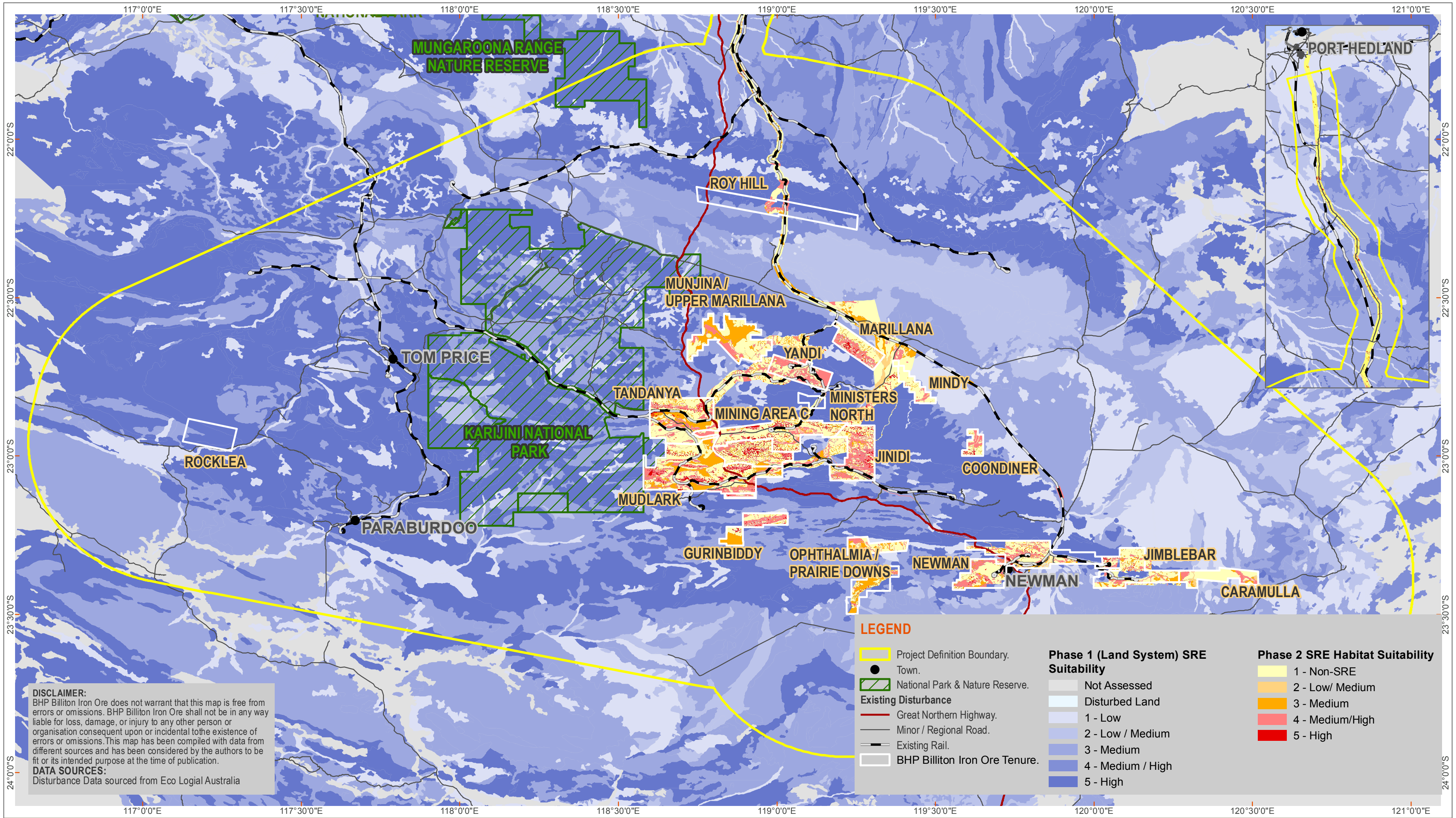

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Figure 31a Short-range endemic invertebrate habitat suitability relative to the Project Definition Boundary (overview)

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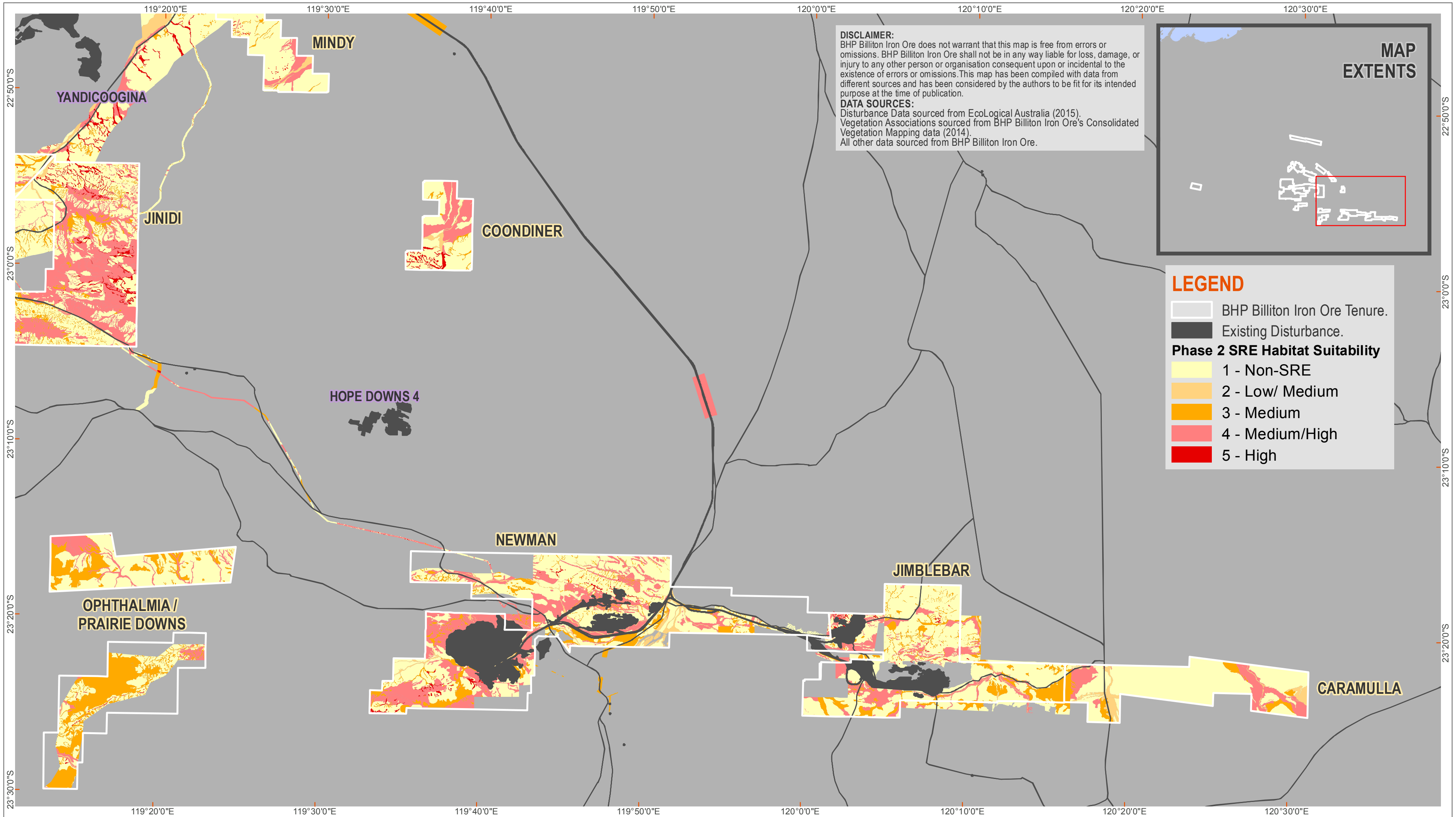

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Figure 31b Short-range endemic invertebrate habitat suitability across BHP Billiton Iron Ore tenure

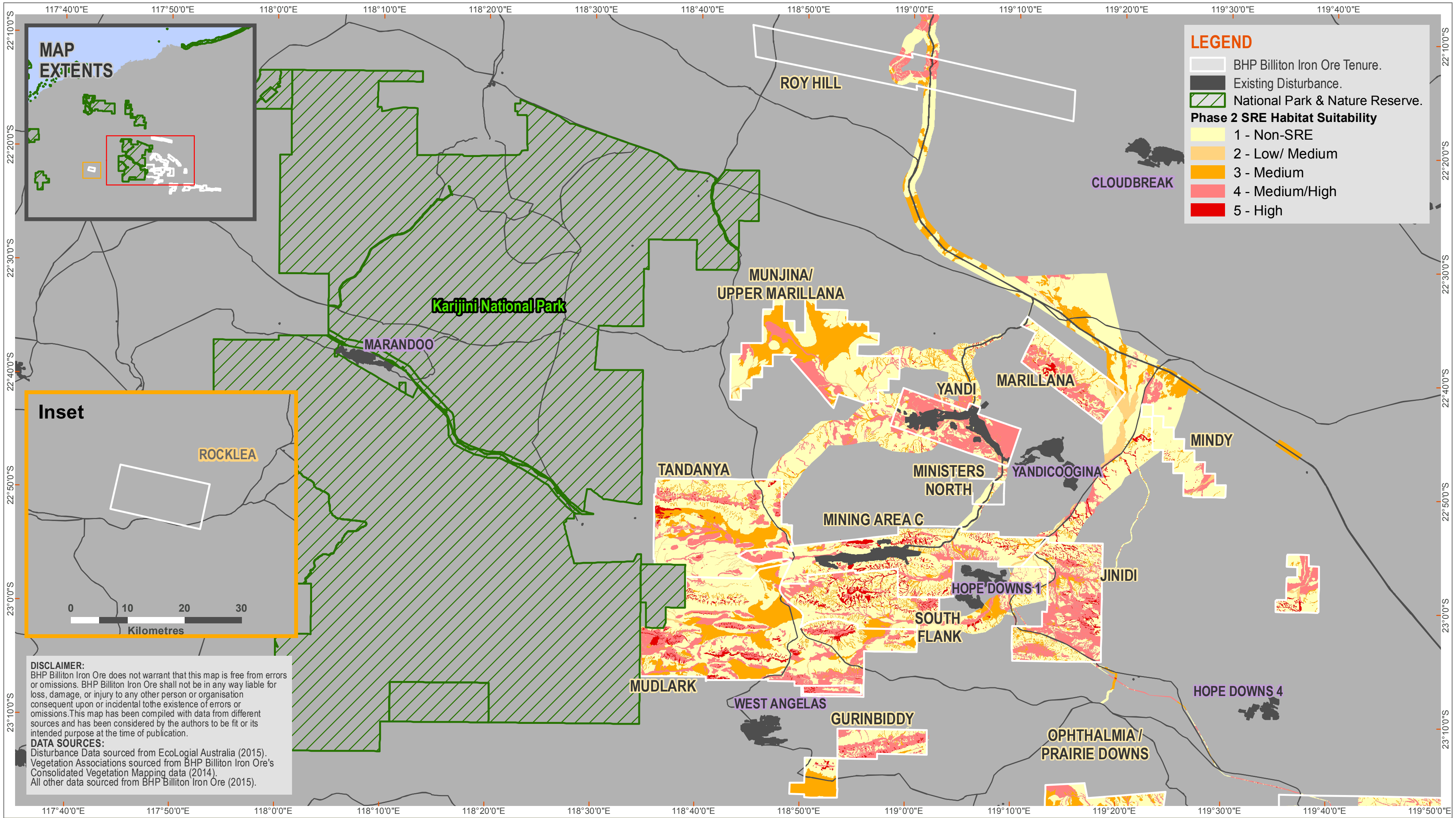

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Figure 31c Short-renage endemic invertebrate habitat suitability across BHP Billiton Iron Ore tenure (central)

8.1.4.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara relevant to biodiversity impacts and the potential impacts to terrestrial fauna linked to these activities are listed in Table 24. A brief description of each potential impact is also provided.

Table 24: Activities and potential impacts to terrestrial fauna

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Removal of vegetation and fauna habitats (direct impact)	Vegetation clearing is required for exploration activities, the construction of mine infrastructure and the extraction and storage of mined ore and waste. The extent of the clearing depends on a number of factors, including (but not limited to): • the size of the development footprint; • the vegetation cover within the footprint; and • the mining and waste disposal methods used (e.g., backfilling versus out-of-pit waste storage). The significance of the environmental impact associated with vegetation clearing depends on (but is not limited to): • the extent of clearing undertaken; • the rarity and ecological function of the vegetation cleared; • the rarity and ecological function of any fauna impacted (directly or indirectly); and • the extent and viability of rehabilitation undertaken. Relative to clearing that has been undertaken for agriculture and in some pastoral areas, the footprints from mining operations are small (Gibson et al. 2015), with 99% of pre-European vegetation remaining through much of the region (Shepherd et al. 2001) (although it is noted that this vegetation has been degraded in places by anthropogenic disturbances such as grazing and altered fire regimes). Nevertheless, these areas are concentrated on the iron ore deposits in the ranges that provide habitat for a number of conservation-significant and habitat-specific species, such as the Pilbara leaf-nosed bat (*Rhinonicterus aurantia*), Pilbara olive python (*Liasis olivaceus barroni*) and western pebble-mound mouse (*Pseudomys chapmani*). Most species have some level of habitat specificity, but for those species that have very specific habitat requirements (e.g. SREs), clearing of this habitat could potentially lead to isolation of individuals or populations. Currently, habitat fragmentation and resulting barriers to movement are minimal in the Pilbara when compared to other parts of the continent (e.g. the West Australian wheatbelt); however fauna movement and usage of the environment may require ongoing consideration with time.
Surface water and groundwater alteration (indirect impact)	In some areas, creeks may be realigned to access mineral deposits, or excess mine water may be pumped into creeks. Alterations to landforms can lead to increased erosion and deposition of sediments in waterways. These aspects could potentially impact on terrestrial fauna and aquatic fauna. Groundwater is abstracted to allow mining of deposits that occur below the groundwater level. Some of this water is used during the mining process, while excess water is typically managed by reinjection, surface water discharge, and storage in holding ponds and dams. These activities may impact terrestrial aquatic flora, subterranean fauna, groundwater-dependent ecosystems and creek integrity. Artificial water bodies (e.g. pit lakes, tailings dams, turkey's nest dams) can have both a positive and a negative impact on flora and fauna. They can provide a long-term source of water that benefits fauna species, particularly water birds; however, terrestrial fauna could potentially become entrained. Artificial water bodies may also promote the establishment and spread of weed species and attract and facilitate the movement of introduced fauna species (e.g. the cane toad (*Rhinella marina*)).
Permanent modification of landforms (direct	The physiography of the Pilbara region is dominated by rugged hills, ridges and a dissected plateau associated with the Hamersley and Chichester ranges, which separate the lower plains and drainage valleys of the Fortescue and De Grey river catchments (Tille 2006). The primary impacts to landforms

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
impact)	associated with BHP Billiton Iron Ore's activities are the modification or removal of these natural landforms (e.g. ridgelines, gullies and gorges), the creation of artificial landforms (e.g. OSAs) and the creation of mine voids. The impacts this has on biodiversity stem from the associated removal or modification of fauna habitat and impact on the ecological function of an area.
Contamination of soils and water (indirect impact)	The primary contaminants relevant to BHP Billiton Iron Ore's operations in the Pilbara are hydrocarbons and acid-forming material. Hydrocarbon contamination could potentially result from spills or leaks associated with hydrocarbon transfer or storage, whereas the contamination from acid-forming material may occur when sulfide-bearing material is extracted as part of the mining process and is inappropriately handled or stored. Hydrocarbons and acid-forming materials are managed by mine sites, but on occasion accidental spills can result in pollution of soils or waterways. Spills on soils are generally localised and can be easily managed. Spills into waterways, including groundwater, can travel large distances and impact on fauna and flora, including subterranean fauna. Such spills may also affect potable water supplies for towns and mining camps.
Introduced species (indirect impact)	Mining activities have the potential to introduce and spread invasive weed species by transporting contaminated soil and seeds, either directly or contained within dirt or soil on machinery. Weeds can alter the characteristics of ecosystems by outcompeting individual species, changing fire patterns, increasing erosion, altering or removing food resources, and removing vegetative cover required by fauna for shelter and protection from predation. Weeds can also directly compete with conservation-significant flora species for environmental resources. Grazing of cattle can lead to degradation of water sources, increased soil disturbance leading to erosion or introduction of weeds, direct spread of weeds, and destruction of fauna habitat (e.g. burrows). Other introduced species compete directly with native fauna for food and shelter resources, while introduced predators also predate on native species, particularly those categorised as critical weight range species. The cane toad contains toxins that are harmful to native fauna when consumed and has been the cause of a catastrophic decline in species diversity and abundance where it is present. This species currently does not occur in the Pilbara, but some models (e.g. Kearney et al. 2008; Elith et al. 2010; Tingley et al. 2013) predict that it will occur in the next 10 to 20 years.
Dust deposition (indirect impact)	Dust deposition from mining operations on adjacent vegetation has the potential to cause a decline in vegetation health and, in extreme cases, lead to plant mortality (e.g. Turner 2013). A study on dust impacts to vegetation at Rio Tinto's West Angelas mine showed that different species display different patterns of least dust accumulation; however, despite this there was no detectable negative impact of dust on plant function (Butler 2009). There are limited studies on the impact of dust on terrestrial fauna; however, those studies that have been undertaken (e.g. Biota 2014), in conjunction with the results of baseline biological surveys and significant species monitoring adjacent to mine sites (e.g. Specialised Zoological 2014), suggest that dust is unlikely to have a significant impact on terrestrial flora and fauna.
Interactions with mining-related infrastructure (indirect impact)	Elevated noise and light levels associated with mining activity can impact on fauna. The direct impacts are typically non-lethal and generally take the form of changes to behaviour, resulting in avoidance of or attraction to an area. Noise and vibrations associated with blasting, drilling and the operation of machinery may cause animals to move from the area. Lighting required for continuous operations has the potential to attract fauna that forage nocturnally on species that are attracted to the light and to force other species to move away from the area. All of these outcomes may alter the local fauna assemblages. Vehicles can often kill terrestrial fauna, and sometimes birds and bats, crossing roads and tracks. These deaths can indirectly lead to the deaths of other species, such as raptors, quolls and goannas, attracted to the road to feed on carcasses that in turn are killed by passing vehicles. These interactions may also alter the composition of vertebrate fauna communities adjacent to roads, increasing the abundance of scavengers (including introduced species, such as foxes) receiving an advantage from increased mortality and reducing species more heavily impacted (e.g. reptiles).

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Fire (indirect impact)	Native fauna and fauna habitats in the Pilbara are adapted to natural fire regimes. Mining activities have the potential to change the frequency of fire by actively extinguishing fires or by causing them. This may result in fire in certain parts of the landscape being too frequent or in other parts being not frequent enough and overly intense when it does occur.

8.1.4.3 MITIGATION

BHP Billiton Iron Ore will apply mitigation measures from the Land and Biodiversity Management toolkit (Figure 17) to manage impacts to terrestrial fauna. A summary of management actions used to mitigate the threatening processes identified in Section 8.1.4.2 is provided in Table 25. Specific examples of the mitigation toolkit being implemented in existing and proposed operations are provided below. These examples build upon the examples referred to for flora and vegetation (Table 16).

Table 25: Potential management approaches for terrestrial fauna

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Removal of vegetation and fauna habitats	• *Avoidance through informed design* by minimising clearing to the smallest area possible and placing waste in-pit where practicable. • *Avoidance* or *minimisation through informed design* by avoiding or minimising clearing of habitat for conservation-significant species through undertaking baseline surveys and, where practicable, altering mine plans to avoid significant habitats. • Avoid unauthorised clearing through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • *Rehabilitate* cleared areas, progressively where possible, using provenance species and *fauna habitat creation*.
Surface water and groundwater alteration	• Undertake appropriate *groundwater and surface water management* to avoid significant impacts to groundwater dependent or riparian areas (refer to Section 8.2.2.3 under Section 8.2.2, Hydrological Processes and Inland Waters Environmental Quality). • Undertake *ecological asset monitoring* where appropriate. • Draft and implement *management plans* for key assets and significant species as described in Section 6.2. • Establish *performance criteria* to maintain terrestrial fauna habitat values.
Permanent modification of landforms	• *Progressive rehabilitation* of altered landforms, where possible, using the Rehabilitation and Decommissioning Management toolkit (Figure 70) using provenance species and *creating fauna habitat* where possible.
Contamination of soils and water	• Undertake appropriate *groundwater and surface water management* to avoid significant impacts to areas with high terrestrial fauna value (refer to Section 8.2.2.3 in Section 8.2.2, Hydrological Processes and Inland Waters Environmental Quality). • Undertake appropriate waste management, chemical and fuel storage procedures to minimise the potential for spills and contamination.
Introduced species	• Undertake *weed control* and *introduced species monitoring and control* to ensure that the Strategic Proposal does not encourage or exacerbate the spread or presence of introduced species. • Undertake *growth media management* in line with the Rehabilitation and Decommissioning Management toolkit (Figure 70) to prevent introduction and spread of weeds. • Undertake appropriate *putrescible waste management* to avoid attracting and maintaining

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
	populations of introduced species. • Undertake *vehicle inspections* as part of introduced species management.
Dust deposition	• Manage dust as described in Section 8.4.
Interactions with mining-related infrastructure	• *Signage of significant habitat,* including speed limits. • Undertake *employee awareness programs*, e.g. inductions, toolbox meetings highlighting fauna issues. • Effectively *manage putresable waste* and guard infrastructure where appropriate.
Fire	• Implement the *fire response procedure* to ensure that fire risk is managed to an acceptable level.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

Terrestrial Fauna Survey Process

BHP Billiton Iron Ore routinely undertakes baseline and targeted surveys across its tenure and the Pilbara region to increase the understanding of the environment in which it operates. An example of a baseline survey program undertaken for vertebrate fauna within BHP Billiton Iron Ore's Marillana and Eastern Ridge tenements is described in Case Study 3, with the application of knowledge obtained summarised in Case Study 4. The knowledge obtained from the research undertaken is also utilised in the project planning and design stages.

Case Study 3: Vertebrate fauna survey process example

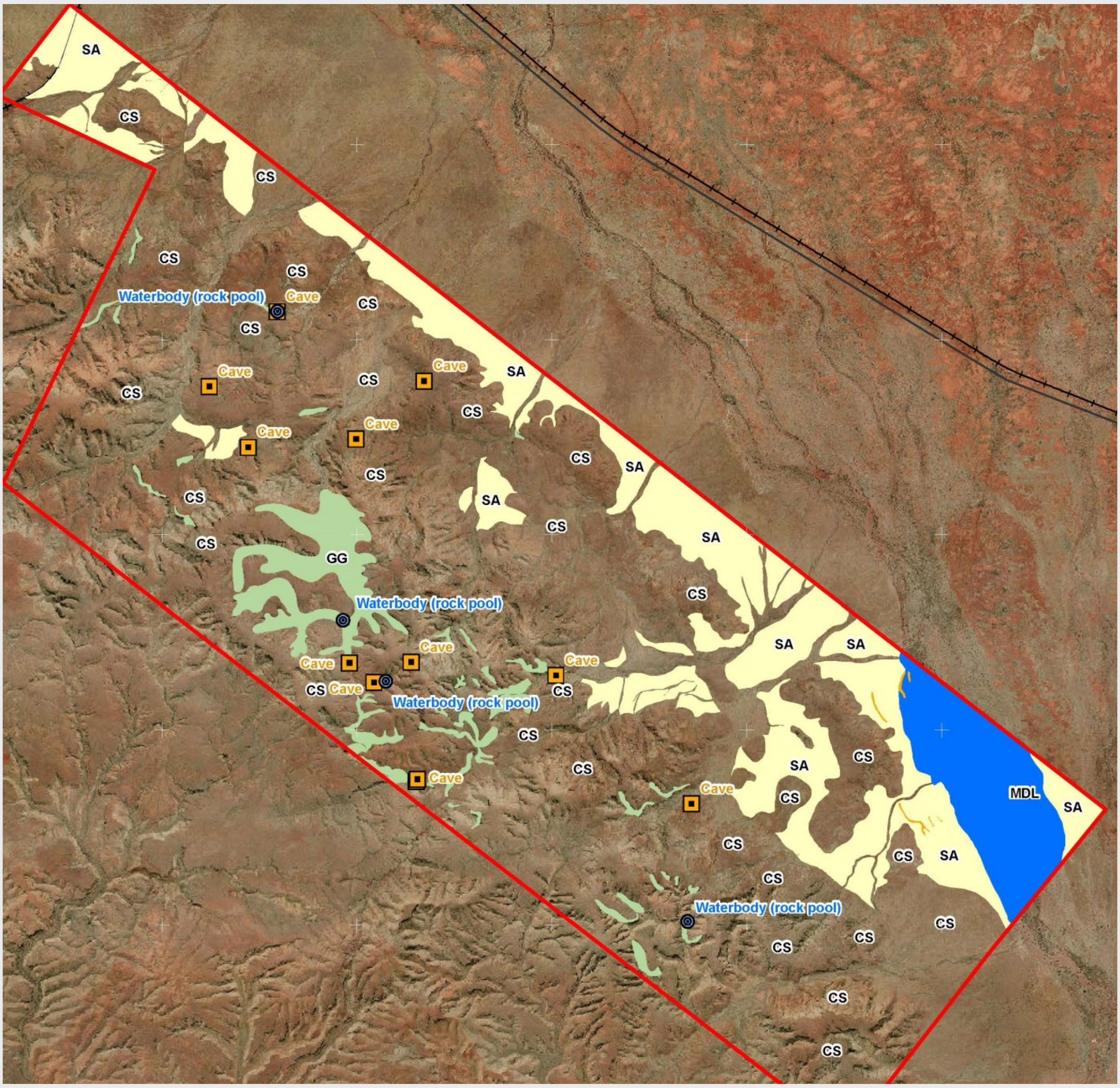
Baseline Vertebrate Fauna Survey

Vertebrate fauna surveys across BHP Billiton Iron Ore's sites generally use desktop analysis and systematic and opportunistic sampling, as well as targeted searches for conservation-significant species, to determine the baseline characteristics of a project area. These methods are in line with the Western Australian EPA's Guidance Statement No. 56 (EPA 2004b), as well as other relevant EPA position statements, and are generally consistent with EPA and DPaW's Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA & DEC 2010).

At least four baseline and one targeted vertebrate fauna surveys have been undertaken within the Marillana tenement since 2005, totalling more than 10,000 combined trap nights. The results from these surveys have indicated that at least eight conservation-significant vertebrate fauna species occur within the tenement. The value of repeat baseline surveys over multiple years and seasons was highlighted in these surveys, as despite similar survey approach (both Level 2 surveys) and conditions, only one conservation significant species was recorded during the first two surveys (Ecologia Environment 2006), and eight were recorded during the second two surveys (Biologic 2013), including the EPBC Act–listed northern quoll and Pilbara leaf-nosed bat and the (now) state-listed ghost bat.

Habitats within the tenement have been mapped and incorporated into BHP Billiton Iron Ore's regional fauna habitat mapping database. Key habitats and features (caves and water bodies) for conservation-significant species have also been recorded.

In November 2015, the northern brushtail possum was listed on the WC Act as a Vulnerable species. Techniques suitable to detect this species were utilised during the baseline surveys; however, this species was not specifically targeted. As there is potentially suitable habitat for this species within the Marillana tenement, in December 2015 BHP Billiton Iron Ore commissioned a survey to specifically target the presence of this species and other key conservation-significant species within the tenement. If this species is found to occur, it along with other species, such as the northern quoll and ghost bat, will be managed as Tier 1 species.



Source: Biologic (2013)

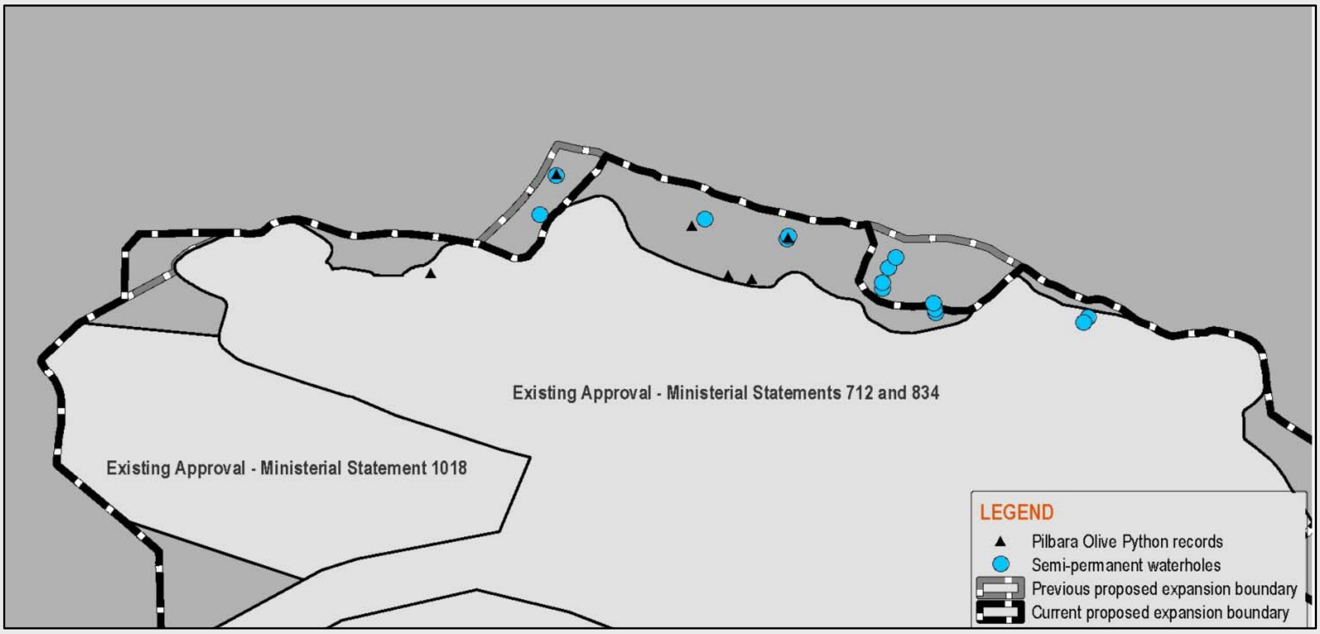
Conservation significant habitat (sandplain (yellow), major drainage line (blue) and gorge/gully (green)) and habitat features (caves (yellow dots) and waterbodies (blue dots)) within the Marillana tenement

Avoidance through Informed Design

Baseline surveys are undertaken within proposed project footprints and adjacent areas; and as part of these surveys, key habitats for conservation-significant species or areas of high conservation value are identified. If habitats of high conservation value are identified within the proposed disturbance footprint, a review of the mine plan is undertaken to determine if these areas can be avoided. Recent examples of where this approach has been implemented are:

- Goldsworthy – In 2004, a significant population of the Pilbara leaf-nosed bat was located adjacent to the then proposed Cattle Gorge mining operations. A 400-m buffer was placed around recorded roosts, the size of which was determined based on observations of this species persisting at caves near other mining infrastructure. Monitoring of bats was undertaken throughout the life of the mining operations (from 2005 to 2014) and is probably one of the longest and most influential bat monitoring programs conducted to date (Specialised Zoological 2014). The monitoring program has shown that bats were continuing to persist within the areas and that recorded changes in bat activity levels were associated with natural fluctuations rather than mining-related impacts (Specialised Zoological 2014; Molhar 2011).

- Eastern Ridge – During a survey to support a currently proposed expansion at BHP Billiton Iron Ore's Eastern Ridge operations, a number of semi-permanent waterbodies were identified (see figure below) that provide habitat for Pilbara olive pythons, and this species was recorded from the area over multiple years, including from a number of these waterbodies. Removal of these waterbodies was considered to have an unacceptable impact to the local population of Pilbara olive pythons, and so the proposed development footprint was revised to avoid removal of some of these habitats (BHP Billiton Iron Ore 2015b).



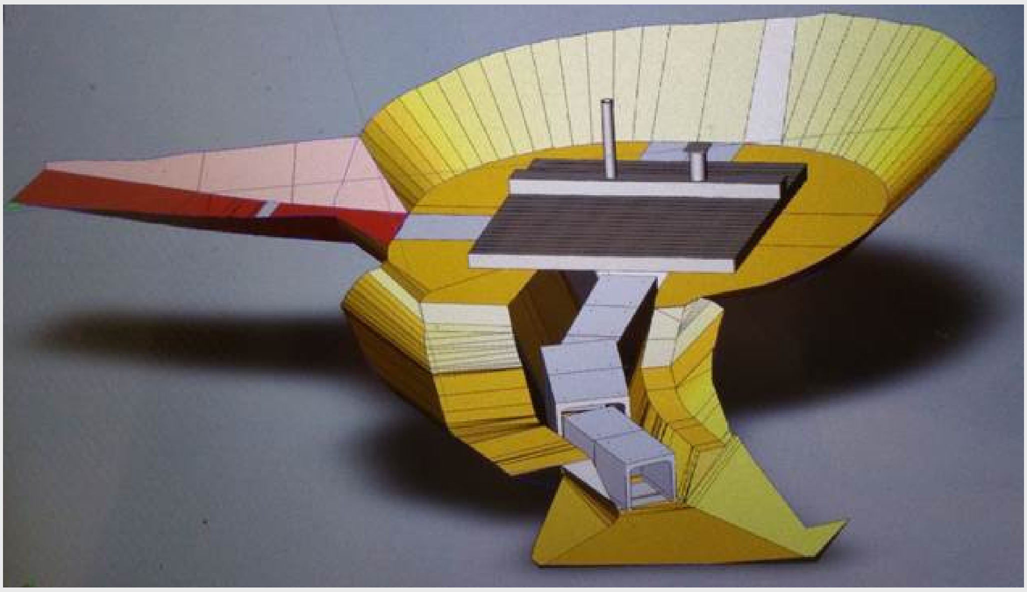
Avoidance of semi-permanent waterholes at Eastern Ridge

Habitat Creation

Prior to 2010, almost all baseline surveys to detect bats undertaken for BHP Billiton Iron Ore had relied on the recording of ultrasonic calls using an Anabat detector. Nine surveys had been undertaken within the vicinity of BHP Billiton Iron Ore's Mining Area C operations, including two targeted bat surveys, during which no ghost bats had been recorded. In 2009 and 2010, Biologic (2011) assessed the presence of ghost bat in the area based on visual searches of caves and documenting the presence of scats or middens. During this survey, 20 caves were recorded that showed evidence of ghost bat use, and a further 19 caves were identified that contained suitable habitat for this species.

Removal of roosting habitat from this area is likely to have an impact on local populations of ghost bats, so BHP Billiton Iron Ore is currently funding studies to better understand the ecology of ghost bats in this area and in particular their use of day and maternity roosts, which appears to differ from those larger roosts in the northern Pilbara and other areas across the Kimberley and Northern Territory that have been the subject of detailed studies (e.g. Boles 1999; Tidemann et al. 1985; Schulz & Menkhorst 1986). The largest colonies in the Pilbara occur outside the Project Definition Boundary where they roost in abandoned mines. Colonies within the Project Definition Boundary are much smaller, and available data suggest that they likely depend on a number of roosts within their range.

In conjunction with regional bat experts, BHP Billiton Iron Ore has recently designed and constructed an artificial roost to mitigate impacts to ghost bats (see figures below).



Ghost Bat Roost Design

The roost has been designed to prevent predation of ghost bats and includes a main roosting chamber and a second intermediate roosting chamber. The roost has been constructed using concrete culverts and structural integrity is engineered for over 200 years. The design also includes a monitoring chute at the roof of the cave to enable non-invasive monitoring to be undertaken to detect the ghost bat's use of the artificial roost. The opening to the completed roost is shown below. It is intended that the monitoring data are made available.

Completed artificial ghost bat roost constructed in the vicinity of Mining Area C

Research

BHP Billiton Iron Ore undertakes research across its current operations to better understand the impacts of its operations on conservation-significant fauna and to apply key learnings through an adaptive management approach to other areas of the business. Case Study 4 provides a further example of a research project that has provided valuable information about the northern quoll that can then be used to inform management during operations, closure and rehabilitation.

Case Study 4: How increased knowledge and an adaptive approach has improved management of the northern quoll

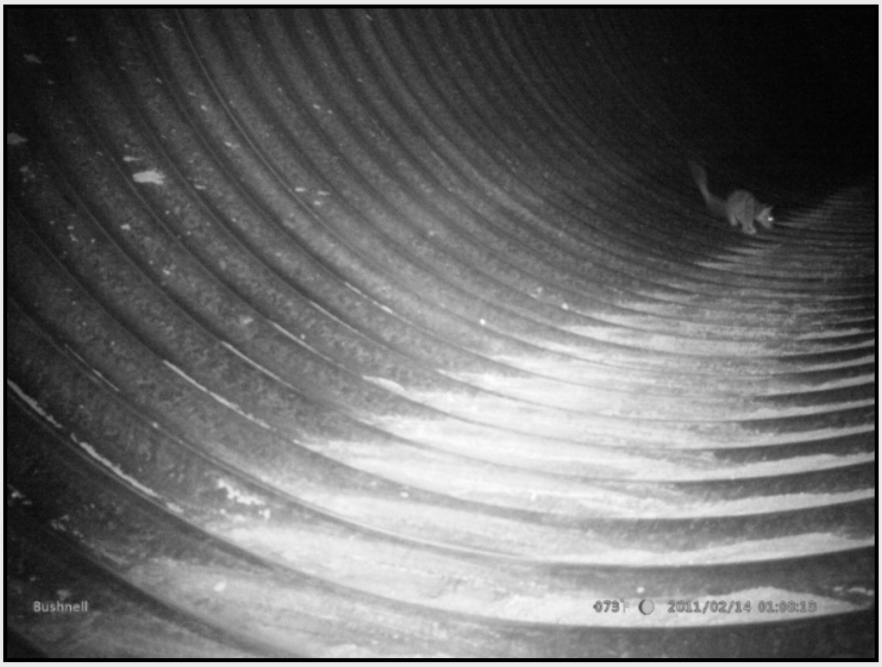
The northern quoll has been recorded from a number of locations within BHP Billiton Iron Ore's tenure, with notable populations occurring at BHP Billiton Iron Ore's Goldsworthy operations (outside the Project Definition Boundary) and along BHP Billiton Iron Ore's railway lines. Numerous studies that contribute to regional knowledge of the species have been either commissioned or supported by BHP Billiton Iron Ore. These include various targeted northern quoll surveys, as well as behavioural, genetic and monitoring studies, that have resulted in improvements to BHP Billiton Iron Ore's management of impacts to the northern quoll (e.g. Spencer et al. 2013; BHP Billiton Iron Ore 2011; Biologic 2010; Ecologia Environment 2010). Three of these are described in more detail below.

A general fauna survey and targeted northern quoll habitat survey were undertaken in preparation for rail expansion at Mooka Siding, during which evidence of several resident northern quoll populations was found (Biologic 2010;). As a result of these surveys, BHP Billiton Iron Ore committed to relocating any individuals found within 50 m of proposed disturbance areas into nearby habitat deemed suitable by the Department of Environment and Conservation (now DPaW). Radio collars were fitted to the relocated individuals, and record was made of the relocation site and date in accordance with an approved clearing permit from the Department of Mines and Petroleum.

A northern quoll ecology and demography study was undertaken by the Department of Parks and Wildlife between 2011 and 2013 with funding provided by BHP Billiton Iron Ore (DPaW 2013). The study examined the effect of disturbance on the northern quoll by comparing a number of ecological factors at seven paired disturbed and undisturbed sites. The results showed that northern quolls foraged and denned in disturbed habitats, although undisturbed habitats were primarily used for denning. Dietary analysis revealed an omnivorous diet, comprised predominantly of invertebrates. Males were observed to move large distances in a relatively short period of time, and male die-off following the breeding season was incomplete in the populations studied. The breeding season was later and occurred over a longer period of time than populations studied outside the Pilbara. The data obtained from this study have been used to manage quoll populations in the vicinity of BHP Billiton Iron Ore's mainline rail, including consideration for timing of construction activities and information that will assist in future rehabilitation activities.

A rail culvert study (Creese 2012) funded by BHP Billiton Iron Ore was undertaken to determine the impact of BHP Billiton Iron Ore's mainline rail on native fauna, including northern quolls. Motion-sensitive cameras, sand pads and track pads were used to determine whether fauna utilised the rail culverts. It was found that rail culverts do facilitate the movement of fauna under the railway; a total of 45 species were recorded using the culverts to cross the railway line (Creese 2012). These comprised 13 reptile species, 19 bird species and 13 mammal species, of which 11 were native. The most frequently recorded species were mammals and included 59 records of the northern quoll (Creese 2012). Culverts to facilitate the general movement of fauna in the Pilbara could be placed at various locations, within different fauna habitat types, and also be used for management of feral fauna species. Evidence of ghost bats using culverts for feeding was also recorded during this work and will be considered for managing impacts to this species.

Increased knowledge gained from research such as this provides an opportunity at the planning and design stage to place rail culverts in habitats that are associated with conservation-significant species. Rail culverts have the potential to facilitate the natural movements of species, especially conservation-significant species such as the northern quoll, across the landscape and minimise the likelihood of mortality due to vehicle or rail collision (Creese 2012).



Source: Sonja Creese.

Northern quoll in rail culvert

Studies such as those described above contribute to a broader understanding and increased knowledge of the northern quoll's ecology and distribution in the Pilbara and are examples of how, through the use of both general and targeted fauna surveys, BHP Billiton Iron Ore can design management controls to avoid (or minimise) impacts and effectively manage conservation-significant species more generally.

8.1.4.4 SIGNIFICANCE OF IMPACTS

The primary basis for the EPA's determination of the likely significance and acceptability of a proposal is whether it is likely to meet the EPA's objectives for each environmental factor. The EPA uses a significance framework to determine the likely significance of a proposal and to make decisions throughout the environmental impact assessment process, as outlined in EPA Environmental Assessment Guideline No. 9 (EPA 2015b). If the EPA considers that a proposal can meet all of its objectives, then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives, then its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives, then its effect on the environment is likely to be unacceptable.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework to determine whether the proposal can meet the EPA objectives for each environmental factor. For the purposes of evaluating significance, the relative impact of each of the development scenarios has been applied to regional and subregional datasets and is discussed further in the following sections.

Impact to Vertebrate Fauna Habitat

There is no regional dataset for vertebrate fauna habitat in the Pilbara, so landform and land system mapping has been used to assess the potential regional impact to vertebrate fauna habitats (these are discussed in detail in Section 8.1.6.1). Eleven landform types occur within the Project Definition Boundary (see Table 31). All of these have more than 99% of their pre-European extent remaining. Those landform types that have the greatest representation within the Project Definition Boundary are Hills and Range' (39.26%), Stony Plains

(18.58%) and Washplains (13.50%). The predicted impacts to these landform types under the Full Conceptual Development Scenario is less than 1% for all landform types, except Washplain,' which has a predicted impact of 1.28%. At the land system level, impacts under the Full Conceptual Development Scenario across the 27 land systems that occur within the Project Definition Boundary are generally considered low (less than 5%). The exception to this is the Wannamunna Land System, with a predicted impact of 10.41% (see Table 35).

The Wannamunna Land System covers a relatively small area of the Pilbara (577 km^2, or 0.3 % of the area surveyed by van Vreeswyck et al. *(*2004)). It is described as 'hardpan plain and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands)' and occurs northwest of Newman along the southern boundary of the Hamersley Range. The hardpan plains that comprise most (56%) of this land system are unlikely to support any breeding populations of conservation-significant species (see Table 21); although the mulga woodlands, which are not constrained to the Wannamunna Land System, do support a number of species (in particular birds and reptiles) that are largely restricted to this habitat type. BHP Billiton Iron Ore considers that impacts to the Wannamunna Land System can be managed to an acceptable level.

Terrestrial ecosystems with a dependency on groundwater are uncommon in the Pilbara and typically restricted to riparian habitats where groundwater is relatively shallow. Riparian vegetation is most important to avifauna communities and some species of conservation-significant fauna that utilise this habitat for denning and as habitat corridors. Some areas that contain permanent or near-permanent sources of water are classified as Priority Ecological Communities (e.g., Fortescue Marsh, Weeli Wolli Spring) and are discussed further in Sections 8.1.2 and 8.2.2.

Fauna habitats that support conservation-significant species or a higher diversity of species are considered to have enhanced conservation value. Most conservation-significant species are restricted to particular habitat types and have not been able to adapt to impacts arising from European colonisation (e.g. land clearing, introduction of feral species (plants and animals), and changed fire regimes).

Table 27 provides a summary of conservation-significant species that have been recorded or may occur in each habitat mapped within BHP Billiton Iron Ore tenements. Sand Plain, Sand Dune, Major Drainage Line, Granite Dome & Boulder Piles, Fortescue Marsh Samphire, Gilgai and Gorge/Gully habitats have the highest number of conservation-significant species records (based on 2014 data) or contain habitat suitable for conservation-significant species (Biologic 2014).

The Sand Plain, Sand Dune, Granite Dome & Boulder Piles, Fortescue Marsh Samphire, and Gilgai habitats largely occur outside of areas that contain mineral deposits targeted by mining companies (however, they may occur in adjacent areas and are therefore subject to indirect impacts) but may be directly impacted by mining infrastructure, such as railway lines (e.g. the western edge of the Fortescue Marsh) or used for obtaining material for rail ballast (Granite Dome & Boulder Piles).

The Major Drainage Line habitat is a widespread and common habitat within the Pilbara; however, due to its linear nature, it covers a relatively small proportion of the area and is important for many species of fauna as it provides dispersal corridors. Mining of channel iron deposits is often undertaken within or adjacent to Major Drainage Line habitat (for example, BHP Billiton Iron Ore's Yandi mine or Rio Tinto Iron Ore's Yandicoogina mine) and can remove or alter this habitat. In addition, Major Drainage Line habitats can be impacted by groundwater abstraction and surplus water discharge, which have the potential to alter the vegetation growing in these areas. Surplus water management is discussed further in Section 8.2.

Gorge/Gully habitats generally occur high in the landscape in the large hills and ranges that cover much of the Pilbara region. These ranges contain high concentrations of iron ore, and many have been targeted by mineral exploration companies for mining. Given this, those species that rely on habitats that occur in the Gorge/Gully habitat are most at risk from implementation of the Full Conceptual Development Scenario. These species include the Pilbara leaf-nosed bat and ghost bat (as the Gorge/Gully habitat is usually where caves are located), northern quoll and Pilbara olive python. Gorge/Gully habitat is well represented in conservation reserves of the Pilbara region (e.g. Millstream Chichester and Karijini national parks) and in the recent pastoral lease exclusion areas (although it is noted that these areas are not exempt from mineral exploration or mining).

Consolidated fauna habitat mapping within BHP Billiton Iron Ore tenure (including miscellaneous licences) provides detailed information on fauna habitats that will be used at the Derived Proposal stage; however does not allow a regional-scale assessment given that the extent of the mapping is restricted to BHP Billiton Iron Ore tenure. This information does, however, identify those habitats that are at higher risk under implementation of the 30% or Full Conceptual Development Scenario, and therefore would be the focus of further investigation or management at the Derived Proposal stage. An overview of each habitat's extent, and proportion that occurs within the 30% and Full Conceptual Development Scenario footprints is provided in Table 26. Those habitats identified to have the highest proportional impact under the Full Conceptual Development Scenarios were Drainage Area (24.5%), Gorge/Gully (30.1%), Minor Drainage Line (28.5%), Crest/Slope (27.7%), Mulga (24.8%) and Hardpan Plain (26.4%).

The Derived Proposal process allows validation of impacts to fauna habitats as described above, considering available contemporary regional or local data (commissioned or undertaken on behalf of BHP Billiton Iron Ore, other mining companies or government or non-government organisations). Validation of impacts to habitat will also consider records of conservation-significant species from within these habitats.

Given the scientific uncertainties associated with the potential ecological impacts of climate change on vertebrate fauna, it is not possible to meaningfully incorporate the impacts of climate change as part of the PERSP. BHP Billiton Iron Ore does recognise that such change is possible, and will incorporate climatic variation into its adaptive management approach and the verification and validation at the Derived Proposal stage.

Table 26: Area of potential impact to mapped fauna habitat types across BHP Billiton Iron Ore tenure.

Habitat Type	Total Area Mapped (ha)	Area Cleared (ha)[1]		
		Existing Development Scenario	30% Conceptual Development Scenario	Full Conceptual Development Scenario
Plains				
Calcrete Areas	8,881	1	598	1,247
Gilgai (cracking clay)	2,681	30	30	257
Granite Domes and Boulders	564	10	10	10
Hardpan Plain	6,112	0	513	1,613
Mulga	33,191	146	1,845	8,230
Sand Dune	68.8	0	0	0
Sand Plain	55,572	600	2,388	6,230
Sandy/Stony Plain	3,866	46	46	46
Stony Plain	44,623	527	2,528	8,675
Ranges				
Crest/ Slope	192,784	3,710	19,665	53,483
Gorge/ Gully	4,553	26	757	1,373
Minor Drainage Line	10,969	136	1175	3,126

Habitat Type	Total Area Mapped (ha)	Area Cleared (ha)[1]		
		Existing Development Scenario	30% Conceptual Development Scenario	Full Conceptual Development Scenario
Riparian Zones				
Drainage Area	37,243	816	4231	9,137
Drainage Line	823	5	5	83
Fortescue Marsh Samphire	367	2	2	2
Major Drainage Line	13,071	211	651	1,570
Disturbed/ Cleared Areas				
Artificial Habitats (NQ habitat)	11	0.1	0.1	0.1

1. Area cleared considers BHP Billiton Iron Ore impacts only, because vegetation condition is mapped only across BHP Billiton Iron Ore tenure. The 30% Conceptual Development Scenario and Full Conceptual Development Scenario includes Existing Development.

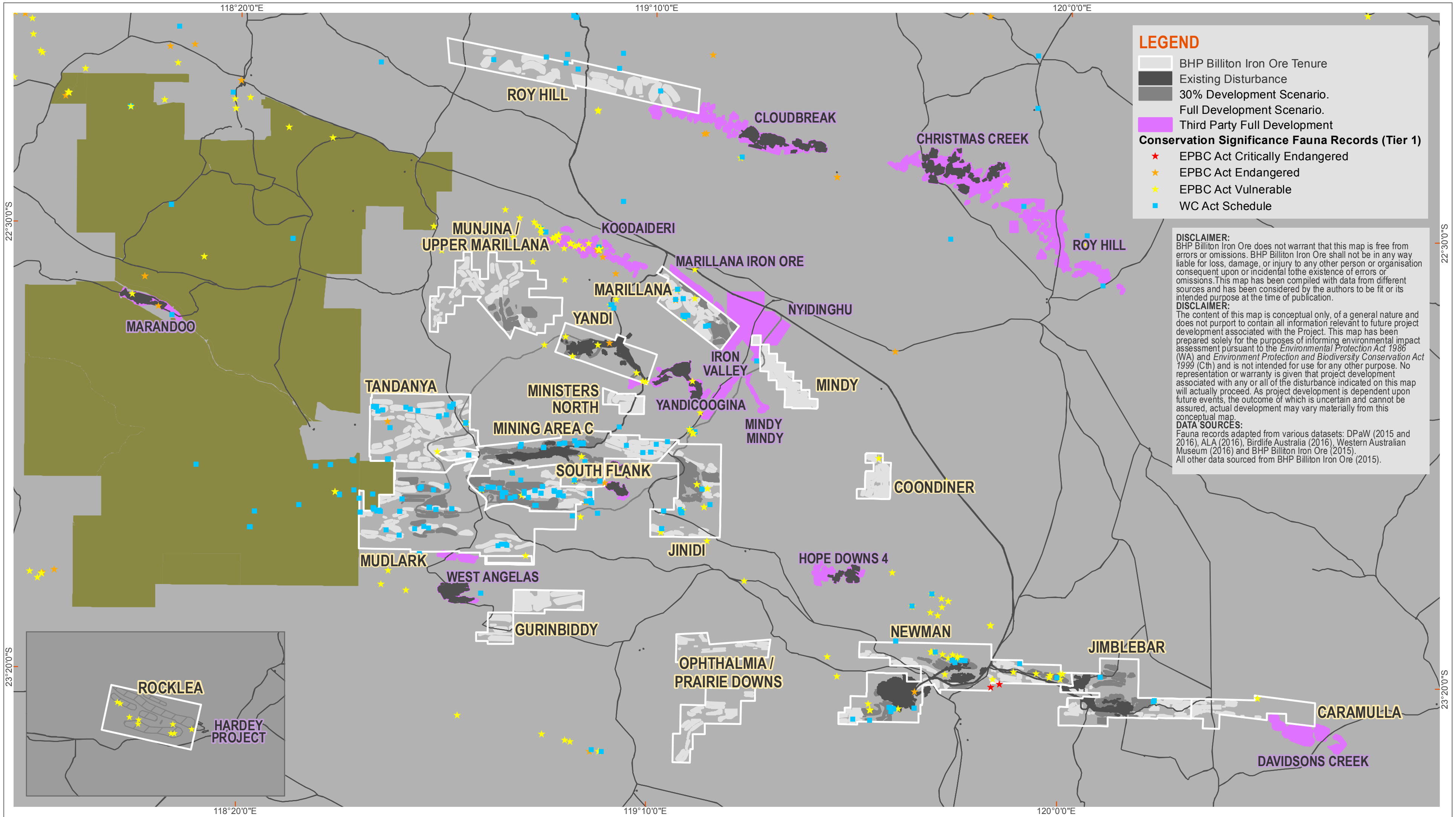
Impact to Conservation-significant Vertebrate Fauna and Habitats

An analysis of conservation-significant fauna records was undertaken in January 2016 to determine conservation-significant species with the greatest potential for impact due to implementation of BHP Billiton Iron Ore's Full Conceptual Development Scenario (BHP Billiton Iron Ore 2016). Details of the data analysis that was undertaken for this project is provided in Appendix 4. The analysis identified 49 conservation-significant species that occur within the Project Definition Boundary.

Sixteen species were identified to be of 'species of interest' indicating potential conservation concern, as more than 5 % of their known Australian records occur within the Project Definition Boundary (Table 27). There are a number of national and state references that define threshold levels for vegetation, but there are none for impacts to species. As many of the conservation significant species present within the Pilbara are either highly mobile or transient, a 5 % threshold was considered a conservative approach to identify species of interest for the purposes of the Strategic Proposal.

A summary of species records for these 16 species, including those present within currently approved areas (BHP Billiton Iron Ore and Third Party) and proposed development footprints under the 30 % Conceptual Development Scenario and Full Conceptual Development Scenario is provided in Table 27.

Five species of conservation significance were identified from the 2015 data to have more than 10% of their known records occurring within the Full Conceptual Development Scenario footprints. These were the Pilbara olive python (14%), ghost bat (18%), Pilbara flat-headed blind-snake (24%), Pilbara barking gecko (17%), and western pebble-mound mouse (29%). An assessment of potential impacts to these conservation-significant species is provided in text.



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Strategic Proposal

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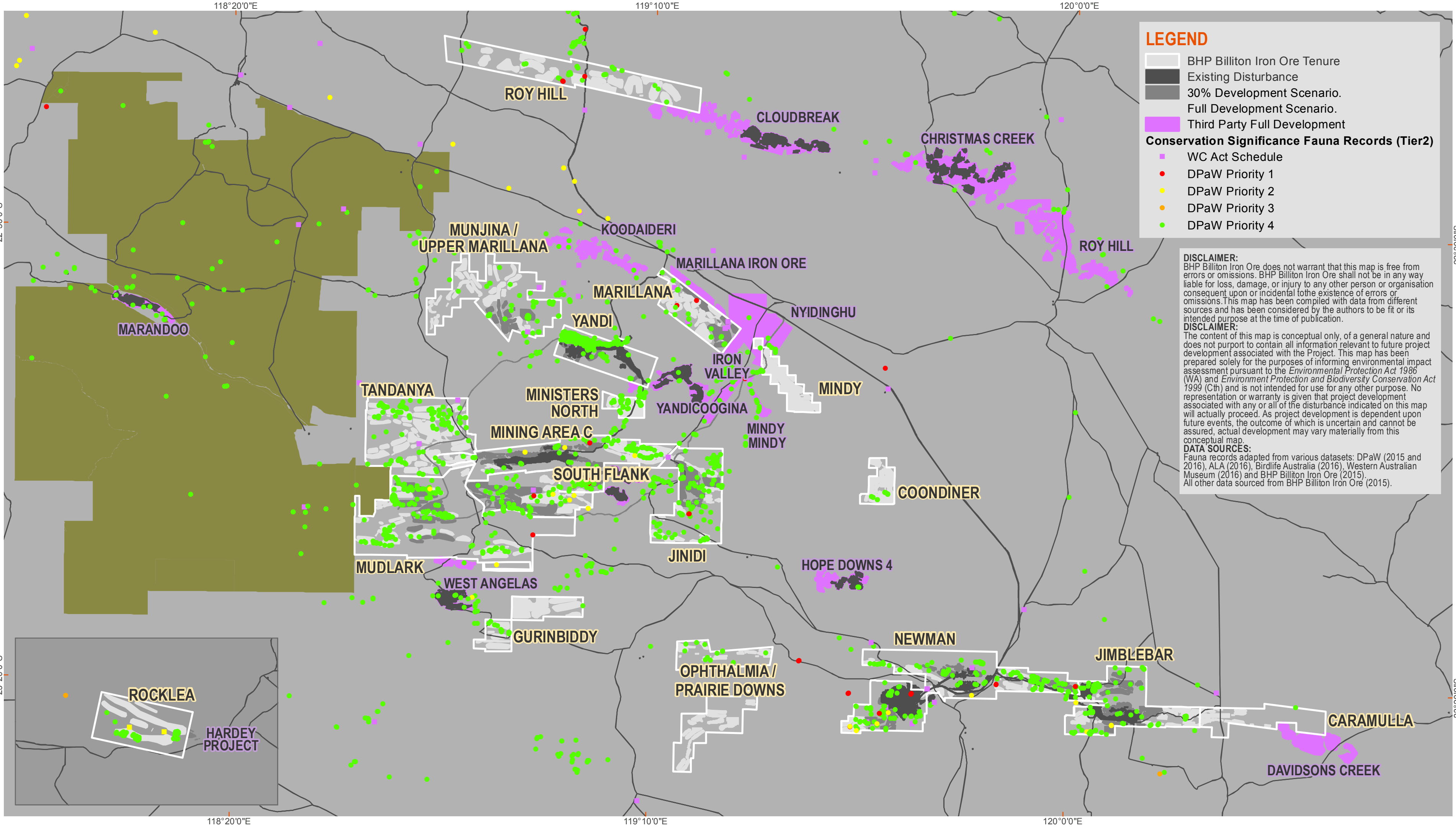
DRAWN: BHP Billiton Iron Ore Environmental Approvals

Figure 32a Cumulative impact to known locations of conservation-significant fauna species from development scenarios (Tier 1 species)



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Strategic Proposal

Figure 32b Cumulative impact to known locations of conservation-significant fauna species from development scenarios (Tier 2 species)

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Table 27: Details of conservation-significant vertebrate fauna species for which more than 5% of known records occur within the Project Definition Boundary

Species	Records		Number of records within development scenarios[1]					Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
EPBC Endangered – TIER 1								
Northern quoll *Dasyurus hallucatus*	3638	1605	403	13	1	14	16	Previously occurred continuously across northern Australia but now fragmented into a number of populations, with the Pilbara population separated from the others by the Great Sandy Desert. Recorded extensively across all four sub-regions of the Pilbara. Inhabits diverse habitats including rocky areas, eucalypt forests, sandy lowlands, shrub-land, grassland and desert. There are few records within the Full Conceptual Development Scenario; therefore at this stage this species is considered to be at low risk from the Full Conceptual Development Scenario. BHP Billiton Iron Ore recognises that this risk may change in the future due to environmental factors such as decline in populations outside of the Pilbara and potential threat of cane toads in northern Pilbara. The Derived Proposal process allows for consideration of environmental change.

Species	Records		Number of records within development scenarios[1]					Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
EPBC Vulnerable – TIER 1								
Pilbara olive python *Liasis olivaceus barroni*	187	185	117	4	1	20	26	Restricted to ranges within the Pilbara, northern Gascoyne and northern Carnarvon regions of Western Australia. In warmer months, prefers riparian habitats with waterholes and rivers. In cooler months, inhabits rocky habitats. There will be an impact under the 30% Conceptual Development and Full Conceptual Development Scenarios, both of which are determined to be moderate. This species is further discussed in text.
Greater bilby *Macrotis lagotis*	2522	251	131	3	0	3	3	Once widespread across semi-arid Australia but now reduced to scattered populations. Still has a relatively widespread distribution, with the majority or records located in the NT. In WA, populations occur across the state but are concentrated in the southwest. Inhabit areas of high rainfall and high temperatures with suitable burrowing habitat such as dunes. As the majority of records occur outside the Pilbara and only two occur in the Full Conceptual Development Scenario, the cumulative risk to this species is considered to be low.

Pilbara leaf-nosed bat *Rhinonicteris aurantia*	389	347	117	0	4	4	9	Restricted to the Pilbara region of WA. Three distinct subpopulations occur: the eastern Pilbara mines and granite, the Hamersley Range, and the Upper Gascoyne. Restricted to caves and horizontal mine shafts with stable, warm and humid microclimates. Occurs over a wide area with relatively few records in the Full Conceptual Development Scenario; however there is a significant roost known from Rio Tinto's Koodaideri project (Rio Tinto 2013). The data from which isn't included in this screening assessment. Based on surveys to date, there have been no significant roosts for this species identified in BHP Billiton Iron Ore tenure; therefore at this stage this species is considered to be at low risk from the Full Conceptual Development Scenario. BHP Billiton Iron Ore recognises that this risk may change in the future given that this species has preference for habitats that occur within mining tenure and its susceptibility to mining related impacts. The Derived Proposal process allows for consideration of new knowledge about this species to validate impacts will be managed to an acceptable level.

Species	Records		Number of records within development scenarios[1]					Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
WC Act Schedule 3 – TIER 1								
Ghost bat *Macroderma gigas*	1821	997	507	35	6	95	179	Once widespread across most of northern Australia, but recent contractions of distribution have left the Pilbara population isolated by the Great Sandy Desert. Forages in a wide range of habitats, but roosts in specific types of caves and horizontal mine shafts. There will be an impact under the 30% Conceptual Development and Full Conceptual Development Scenarios, both of which are considered to be moderate. This species is further discussed in text.
DPaW Priority 1 – TIER 2								
Pilbara flat-headed blind-snake *Anilios ganei*	85	84	68	4	1	11	20	Confined to the Pilbara region of Western Australia. Rarely encountered due to mostly living underground. Associated with moist gorges and gullies (Wilson & Swan 2010). Potentially associated with a wide range of other stony habitats as well as Mulga woodlands, therefore could possibly be found in many habitats of the Pilbara (Biologic 2015). There will be an impact under the 30% Conceptual Development and Full Conceptual Development Scenarios, both of which are considered to be moderate. This species is further discussed in text.

Black-lined ctenotus *Ctenotus nigrilineatus*	62	57	5	0	0	0	0	Restricted to the Pilbara region of WA. Only known from a few patchily distributed records, primarily in the Chichester subregion. Recorded from spinifex habitat at the base of granite outcrops. Occurs over a relatively wide area with no records in the Full Conceptual Development Scenario, so determined to be at low risk.
DPaW Priority 2 – TIER 2								
Spotted ctenotus *Ctenotus uber johnstonei* DPaW Priority 2	45	22	17	0	0	0	0	Distributed across the northwest of WA. Specimens occurring in the Pilbara may be grouped with *Ctenotus uber johnstonei*, or they may belong to a currently undescribed taxon, in which case they would have no official conservation status. As a precautionary approach, the Pilbara taxon is treated as the Priority 2 subspecies. Habitat is mapped as stony plain and mulga. No records in the Full Conceptual Development Scenario. Risk considered low.
Pilbara barking gecko *Underwoodi-saurus seorsus*	30	27	26	0	0	1	5	A relatively newly described (2011) restricted-range species occurring at mid-elevations in the Hamersley Ranges. Known from two separate areas approximately 175 km apart (Biologic 2014). It is unknown whether its distribution is continuous between these areas, or if it occurs as a series of isolated populations. There will be an impact under the 30% Conceptual Development and Full Conceptual Development Scenarios, both of which are considered to be moderate. This species is further discussed in text.
DPaW Priority 3 – TIER 2								

Spectacled hare-wallaby *Lagorchestes conspicillatus leichardti*	92	48	10	0	0	0	0	Historically occupied nearly the entire northern half of Australia, but now occurs only patchily from the Pilbara in WA across the Northern Territory and into Queensland. Inhabits tropical grasslands and seeks shelter in spinifex hummock during the day. Occurs over a wide (if scattered) area with no records in the Full Conceptual Development Scenario, so determined to be at low risk.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
DPaW Priority 4 – TIER 2								
Brush-tailed Mulgara *Dasycercus blythi*	2534	686	362	1	6	7	12	Distributed widely across central and inland Australia including WA, the NT and SA. Exact ranges are difficult to determine due to past nomenclature confusion with *D. cristicauda* and *D. hillieri*, which were synonymised and then subsequently split (Woinarski et al. 2014). Inhabits spinifex grasslands. Occurs over a wide area with relatively few records in the Full Conceptual Development Scenario, so risk therefore determined to be low.
Short-tailed mouse *Leggadina lakedownensis*	659	158	51	2	2	2	2	Distributed in discontinuous populations across northern arid Australia from the Pilbara in WA across the NT to Cape York in QLD. In the Pilbara, inhabits a variety of habitats including spinifex grasslands, *Acacia* shrub-lands, sandy soils, cracking clays and stony ranges. As the majority of records occur outside the Pilbara and there are relatively few records in the Full Conceptual Development Scenario, the risk to this species is considered low.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Fortescue grunter *Leiopotherapon aheneus*	45	35	12	0	0	0	0	Has a restricted distribution within the Pilbara and is only known from the Fortescue, Robe and Ashburton river systems. Considered reasonably common within this range, inhabiting clear freshwater streams and pools over sandy and rocky bottoms. Due to the high likelihood of additional records of this species occurring within its range and no records in the Full Conceptual Development Scenario, the risk is considered to be low.
Lined soil-crevice Skink *Notoscincus butleri*	144	124	14	0	0	0	0	Restricted to the western half of the Pilbara region of WA, with one isolated record in the southwest of the Great Sandy Desert. Inhabits arid, rocky habitats in spinifex-dominated areas near creeks and river beds. With no records in the Full Conceptual Development Scenario, the risk is considered low.
Western pebble-mound mouse *Pseudomys chapmani*	3523	3396	2967	194	50	538	1005	Recently considered restricted to the Pilbara after experiencing significant declines in range throughout the Gascoyne and Murchison regions (van Dyck and Strahan 2008). Mounds are common but sparsely distributed within their abundant habitat of gentle slopes covered in small stones and gravel. There will be an impact under the 30% Conceptual Development and Full Conceptual Development Scenarios, both of which are considered to be moderate. This species is further discussed in text.

Species	Records			Number of records within development scenarios[1]				Significance of Impact
	Total[2]	Pilbara Area[3]	Project Definition Boundary	Existing Development Scenario	Reasonably Foreseeable Third Party	30% Conceptual Development Scenario	Full Conceptual Development Scenario	
Long-tailed dunnart *Sminthopsis longicaudata*	160	36	14	2	0	2	2	Highly patchy distribution across arid inland regions of WA and the NT. Habitat includes rugged rocky landscapes that support mulga and spinifex, or tall open shrubland and woodlands. Recorded over a wide area with relatively few records in the Full Conceptual Development Scenario, so risk considered low.

1. Development Scenarios:
- Existing Development Scenario includes existing BHP Billiton Iron Ore and third party developments.
- Reasonably foreseeable third party includes future approved or proposed third party developments and does not include existing developments.
- 30% Conceptual Development Scenario includes existing development, reasonably foreseeable third party developments and BHP Billiton Iron Ore's 30% Conceptual Development Scenario.
- Full Conceptual Development Scenario includes existing development, reasonably foreseeable third party developments and BHP Billiton Iron Ore's Full conceptual Development Scenario

2. Total records represents the total number of records available for that species.
3. Pilbara area refers to a search area that encompasses the Project Definition Boundary. Refer to Appendix 4 for further detail.

Pilbara olive python **– TIER 1**

The Pilbara olive python is largely restricted to the Pilbara region of Western Australia, whilst the northern subspecies of olive python (subspecies *olivaceus*) occurs from the Kimberley to western Queensland. It is listed as Vulnerable under the EPBC Act and the WC Act (Schedule 3).

A recent review (February 2016; see Appendix 4) identified 187 records for the Pilbara olive python, of which 117 occurred within the Project Definition Boundary, 20 (approximately 11%) occurred within the 30% Conceptual Development Scenario footprints (19 within BHP Billiton Iron Ore tenements) and 26 (approximately 14%) occurred within the Full Conceptual Development Scenario footprints (25 within BHP Billiton Iron Ore tenure). It is a cryptic species that is difficult to specifically target during fauna surveys (DotE 2008), so this number is unlikely to represent its abundance and distribution within the Pilbara. There is currently no population estimate for the Pilbara olive python although it is believed to have sizable populations in areas (e.g. the Burrup Peninsula), and some of these are restricted from threatening processes (Pearson 2003).

The Pilbara olive python has a strong preference for riparian habitats during warmer months when hunting for prey but utilises rocky habitats at other times of the year (Doughty et al. 2011). Waterholes and billabongs form an important component of the python's habitat, as it is able to ambush prey species that come to drink (Pearson 2003; DotE 2014c). Outside of warmer months, the Pilbara olive python occupies rocky habitats, such as escarpments, mesas, overburden heaps (at Pannawonica), and caves and gorges (Doughty et al. 2011). A large proportion of its habitat is conserved in Karijini National Park (Pearson 1993).

A number of threats to the Pilbara olive python have been identified, with the main threats considered to be predation or loss of food sources due to predation by introduced species and loss of habitat (DotE 2008). Loss of habitat is the primary cause of impact to the Pilbara olive python arising from implementation of the Full Conceptual Development Scenario, particularly removal of riparian vegetation and water holes which are used by the species for hunting.

BHP Billiton Iron Ore recognises that the Pilbara olive python will require considered management during implementation of the Strategic Proposal. The Derived Proposal process allows the validation of impacts to Pilbara olive python populations, with consideration of detailed mine planning and design, and up-to-date information on species ecology and impacts. This species will be managed as a Tier 1 species, and management approaches will be applied as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to the Pilbara olive python can be managed to an acceptable level.

Ghost bat **– TIER 1**

The ghost bat occurs across northern Australia from the Pilbara to Queensland. It was recently (November 2015) listed as Vulnerable under Schedule 3 of the WC Act and is under consideration for listing under the EPBC Act (DotE 2015b).

A recent review (February 2016; see Appendix 4) identified 1821 records for the ghost bat, of which 997 occurred within the Pilbara area, 507 occurred within the Project Definition Boundary, 95 (approximately 10% of Pilbara records) occurred within the 30% Conceptual Development Scenario footprints (89 within BHP Billiton Iron Ore tenements) and 179 (approximately 18% of Pilbara records) occurred within the Full Conceptual Development Scenario footprints (173 within BHP Billiton Iron Ore tenure).It is likely that the majority of these records are from bat call detectors and therefore may not necessarily reflect the location of roosts. Further, this number is almost certainly biased towards records on mining tenure due to the large amount of survey work undertaken by biological consulting companies for environmental approvals. Nevertheless, the data do demonstrate that this species is commonly recorded and are consistent with the findings of McKenzie and Bullen (2009).

The ghost bat occurs in all four Pilbara subregions, but within these subregions it occurs as clustered populations, particularly where large populations roost in abandoned mines and adits in the Chichester subregion (see Figure 33). Based on data available as of 2014, Biologic and Bat Call WA (2014) estimated the Pilbara population to be between 1,800 and 2,400 individuals, with the Chichester population comprising most of these (Chichester population estimated at 1,500 to 2,000 individuals; Hamersley population estimated at 300 to 400). A recent national estimate for Australia was given as less than 10,000, and this is expected to decline at a rate of more than 10% over the next 24 years (three generations) (Woinarski et al. 2014). At a national level, this species' persistence is under threat due to habitat loss and fragmentation, climate change and mortality due to interactions with infrastructure (Woinarski et al. 2014), and there is recent evidence that it may also be impacted by consumption of cane toads (Norm McKenzie, Department of Parks and Wildlife, pers. comm., 2014; Purtill 2014). Given this, all populations of this species are considered to be of conservation value, particularly those that occur at or beyond the limit of the cane toad's estimated future distribution in the Pilbara or those that will facilitate a shift in distribution with changing climate.

A population of ghost bats occurs within BHP Billiton Iron Ore's tenements east of Karijini National Park (in the vicinity of Mining Area C), and there is evidence of breeding occurring in this area (at Rio Tinto's West Angelas tenure (Armstrong & Anstee 2000) and BHP Billiton Iron Ore's South Flank tenure (Biologic in prep.)). There are few known records of breeding in the Hamersley Range, so the presence of a breeding colony in this area is considered to be significant at a local (population) and subregional (Hamersley) level. Unlike the large maternity roosts that occur in the Chichester subregion (e.g. the Klondyke Queen mine, which supports over 100 ghost bats), the colonies in this area are small, numbering up to 20 individuals.

BHP Billiton Iron Ore is currently funding studies to better understand the ecology of ghost bats in this area and in particular their use of day and maternity roosts, which appears to differ from those larger roosts in the northern Pilbara and other areas across the Kimberley and Northern Territory that have been the subject of detailed studies (e.g. Boles 1999; Tidemann et al. 1985; Schulz & Menkhorst 1986). The largest colonies in the Pilbara occur outside the Project Definition Boundary where they roost in abandoned mines (see Figure 33). Colonies within the Project Definition Boundary are much smaller, and available data suggest that they likely depend on a number of roosts within their range. Ghost bat populations in the Chichester subregion are considered significant; and if impacted by habitat loss (due to collapse or reworking of mine adits) or from the arrival of cane toads, those populations within the Project Definition Boundary will become more important regionally. Through BHP Billiton Iron Ore's approach to adaptive management, should the populations of ghost-bats within the Project Definition Boundary require an increased management focus, impacts to populations will be able to be managed to an acceptable level.

BHP Billiton Iron Ore recognises that the ghost bat will require considered management during implementation of the Strategic Proposal. The Derived Proposal process allows the validation of impacts to ghost bat populations discussed above, with consideration of detailed mine planning and design, and up-to-date information on species ecology and impacts. This species will be managed as a Tier 1 species, and management approaches will be applied as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to the ghost bat can be managed to an acceptable level.

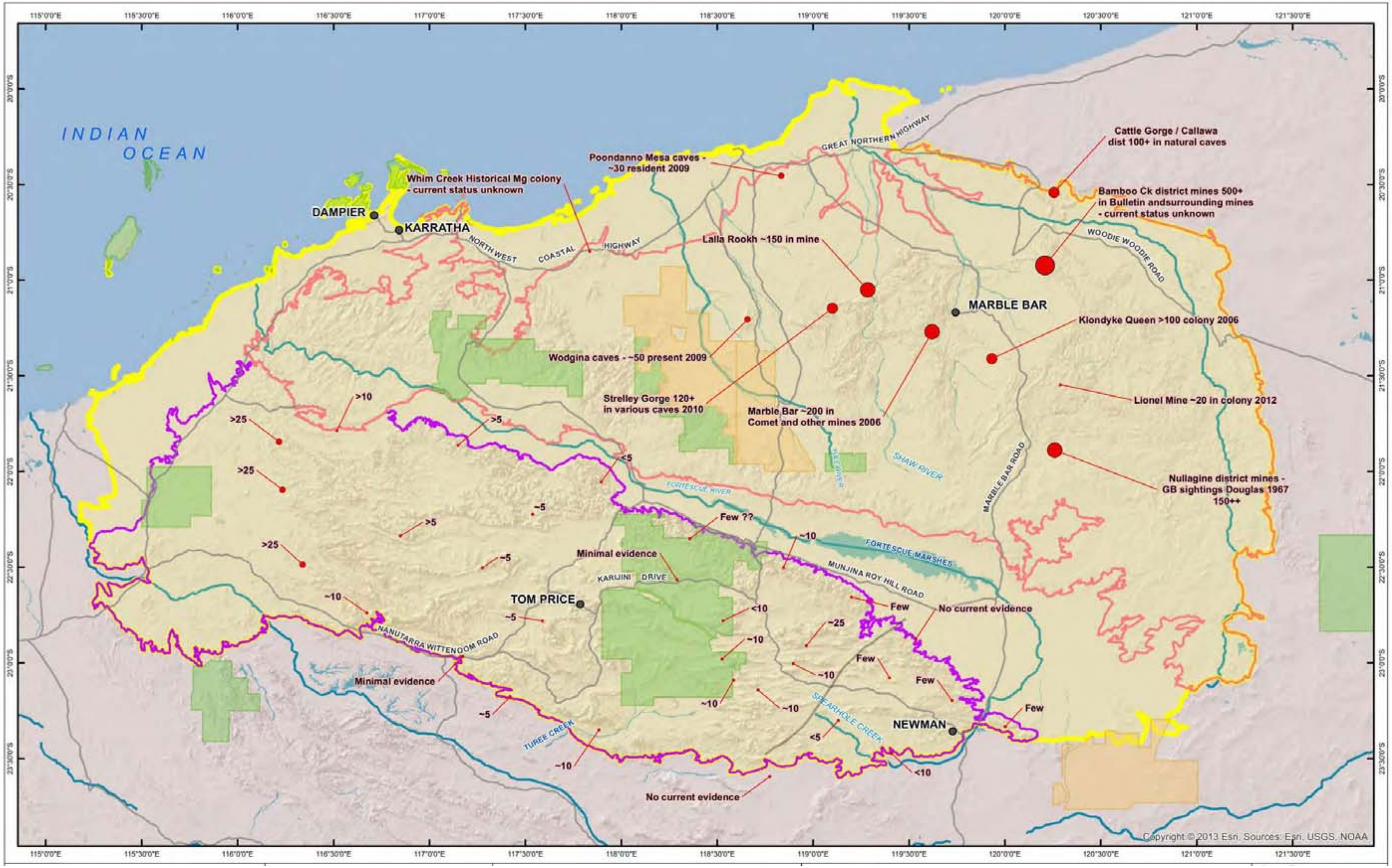

Figure 33: Graphical representation of the 2014 population estimate for the ghost bat in the Pilbara.

***Western pebble-mound mouse* – TIER 2**

The western pebble-mound mouse is considered largely endemic to the Pilbara and is currently listed as a Priority 4 species by the DPaW. This species is common in suitable habitat (the gentle slopes of hills with substrates containing pebbles of a specific size (Ford & Johnson 2007; Start et al. 2000) and is commonly recorded during biological surveys where its presence is evident due to the presence of distinctive mounds.

A recent review (February 2016; see Appendix 4) identified 3523 records for the western pebble-mound mouse, of which 2967 occurred within the Project Definition Boundary, 538 (approximately 15%) occurred within the 30% Conceptual Development Scenario footprints (488 within BHP Billiton Iron Ore tenements) and 1005 (approximately 29%) occurred within the Full Conceptual Development Scenario footprints (955 within BHP Billiton Iron Ore tenure). The high proportion of records within BHP Billiton Iron Ore tenure likely reflects the volume and survey intensity of biological survey work undertaken on behalf of BHP Billiton Iron Ore during the past decade.

The majority of records for the western pebble-mound mouse correspond with identification of mounds; and although it is not possible to tell if these mounds are currently active or inactive (due to the fact that this information is not provided or usage changes over time), the information does provide a relatively accurate picture of the distribution of this species within the Pilbara. Recording of inactive mounds may, however, artificially inflate the known records of this species, despite the fact that abandoned mounds may be reused.

It is estimated that approximately 32.5% of known records for the pebble-mound mouse occur within the proposed footprints for the Full Conceptual Development Scenario. This species' habitat is considered widespread and common, and it is known to occur in four of the Pilbara conservation reserves (Gibson & McKenzie 2009). While there are relatively few records for this species within the conservation reserves, this likely reflects the lack of detailed surveys within these areas compared to mining tenure. Consequently, the perceived impacts from the Full Conceptual Development Scenario identified as a result of the known records of this species are considered to not accurately reflect the likely impacts to the species.

BHP Billiton Iron Ore considers that impacts to the pebble-mound mouse can be managed to an acceptable level with the application of mitigation measures identified in the Land and Biodiversity Management toolkit Figure 17). This is in part due to the distribution of the species being considered widespread and common and its occurrence outside of mining tenure within the Project Definition Boundary.

***Pilbara barking gecko* – TIER 2**

The Pilbara barking gecko is a recently described species (having been distinguished from the more widespread and common *Underwoodisaurus milli*) that is endemic to the Pilbara and is currently listed as a Priority 2 species by the DPaW. It is believed to be rare and has a relatively small distribution for a vertebrate (Doughty & Oliver 2011), with current records spanning a distance of approximately 240 km. It is unknown whether its distribution is continuous between these areas or if it occurs as a series of isolated populations. It is a saxicoline (Family) species; and given the amount of available habitat, it is considered very likely that there are additional records within this known range; however, due to the large amount of surveying undertaken in the Pilbara, it is considered unlikely that its distribution is much larger than the current range estimate and probably does not extend beyond the Hamersley subregion. Further, it appears to be a relictual species (it presently occurs in a restricted area, but its original range was far wider in the past), and the possible effects of increases in global temperature in the coming decades are of particular concern (Doughty & Oliver 2011).

A recent review (February 2016; see Appendix 4) identified 30 records for the Pilbara barking gecko, of which 26 occurred within the Project Definition Boundary, 1 (approximately 3%) occurred within the 30% Conceptual Development Scenario footprints (individual was recorded within a BHP Billiton Iron Ore tenement) and 5 (approximately 17%) occurred within the Full Conceptual Development Scenario footprints (all within BHP Billiton Iron Ore tenure)[6]. Further surveys within the species' range are likely to uncover more records.

The rocky habitats preferred by this species are considered prospective for mining, and implementation of the Full Conceptual Development Scenario is likely to disturb a portion of its currently documented preferred habitat within the eastern Hamersley Range. Nevertheless, a large portion of this species' inferred range occurs within Karijini National Park; and while there are no confirmed records from within the park, it almost certainly occurs there.

Until further research is undertaken on the ecology of this species, it is difficult to accurately determine impacts from the Full Conceptual Development Scenario. The information that is currently available for this species, however, indicates that it is almost certainly uncommon and range-restricted and has a preference for rocky habitats within the Hamersley Range that occur within the Project Definition Boundary.

BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for terrestrial fauna. The Derived Proposal process allows the validation of impacts to the Pilbara barking gecko discussed above, with consideration of detailed mine planning and design and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to the Pilbara barking gecko can be managed to an acceptable level.

***Pilbara flat-headed blindsnake* – TIER 2**

The Pilbara flat-headed blindsnake is endemic to the Pilbara region and is currently listed as a Priority 1 species by the DPaW. It is a fossorial species, and little is known about its ecology, but it appears to occur in a range of habitats: Wilson and Swan (2010) state that it is associated with moist gorges and gullies, and Biologic (2015) has identified it as potentially occurring in the Calcrete Areas, Mulga, Crest/Slope and Gorge/Gully habitats mapped within BHP Billiton Iron Ore tenure.

A recent review (February 2016; see Appendix 4) identified 85 records for the Pilbara flat-headed blindsnake, of which 68 occurred within the Project Definition Boundary, 11 (approximately 13%) occurred within the 30 % Conceptual Development Scenario footprints (10 within BHP Billiton Iron Ore tenements) and 20 (approximately 24%) occurred within the Full Conceptual Development Scenario footprints (19 within BHP Billiton Iron Ore tenure). With the exception of one record that occurs in the vicinity of Pannawonica[7], the current distribution of the Pilbara flat-headed blindsnake covers approximately 10,000 km^2.

As with the Pilbara barking gecko, there is little information available on the ecology of the Pilbara flat-headed blindsnake and its distribution, which makes it difficult to assess impacts of the development on this species. It is cryptic and difficult to study and has a bias to records collected in BHP Billiton Iron Ore tenure during baseline biological surveys. The habitat from which it has been recorded is widely distributed within the Hamersley Range, including within Karijini National Park; and it could therefore be reasonably expected to occur more widely within this habitat. Its cryptic nature, the lack of specific and reliable survey techniques, and relatively low survey intensity outside of mining tenure has likely precluded it from being recorded more widely within the Pilbara.

BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for terrestrial fauna. The Derived Proposal process allows the validation of impacts to the Pilbara flat-headed blindsnake discussed above, with consideration of detailed mine planning and design, and up-to-date information on species ecology and impacts. This species will be managed as per the Land and Biodiversity Management toolkit (Figure 17) to meet the objectives described in Section 8.1.1.1. On this basis, BHP Billiton Iron Ore considers that impacts to the Pilbara flat-headed blindsnake can be managed to an acceptable level.

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[6] This total does not included two recent (unpublished) records obtained of geckos sheltering in caves in BHP Billiton Iron Ore's South Flank project area and a record from Karijini National Park that is only known from a photograph and for which no coordinate has been provided.

[7] The record is approximately 280 km from the nearest record and was made in 1991. There have been no subsequent records from this area, and therefore this record is considered to be possibly incorrect.

Impacts to Short-range Endemic Invertebrate Fauna

Potential for impacts to SRE invertebrate fauna were assessed using SRE habitat suitability mapping undertaken by Biologic for both Phase 1 (regional scale ‘Study Area’) and Phase 2 (tenure-scale) of the SRE impact assessment (see Appendix 5), Detailed maps for each BHP Billiton Iron Ore tenement are provided in Appendix 5. The mapping was used to inform a risk rating for the potential level of impact for each habitat unit from its extent within and outside of the Full Conceptual Development Scenario footprint, and the factors increasing the likelihood of SRE species occurring. From this, priorities for future management were derived. A summary for each BHP Billiton Iron Ore tenement is provided in Table 28.

There is substantial variation in the habitat requirements and ranges of SRE species; and many millipedes, pseudoscorpions and spiders are likely to have linear ranges of less than 50 km (Car & Harvey 2013; Harms & Framenau 2013). In some cases, such as goblin spiders in the genus *Opopaea* and keeled millipedes of the genus *Boreohesperus*, many species are known only from the type locality and are unlikely to be more widespread, thus occupying ranges of a few kilometres at most. Some other species, such as wall crab spiders of the family Selenopidae may be more widely distributed but still have a total range below the current threshold of SRE status of 10,000 km^2 (Harvey 2002).

The variability in ranges and preferred habitats of SRE invertebrate species is sufficiently large that caution must be applied to predictions about the degree of potential threat from the Full Conceptual Development Scenario. However, mapped areas of Low and Low-Medium suitability may require no consideration of SRE fauna, mapped areas of Medium suitability habitat may require desktop investigations, and mapped areas of Moderate-High or High suitability habitat may require targeted site-specific investigations. The potential level of impacts and potential priorities for future management of SRE habitat provided for each BHP Billiton Iron Ore tenement in Table 28 will be validated at the Derived Proposal stage using information such as detailed mine planning design, updated survey data, taxonomic updates and publicly available regional data.

BHP Billiton Iron Ore recognises that validation of the potential impacts and appropriate mitigation at the Derived Proposal stage are required to demonstrate that impacts to SREs can be managed to an acceptable level. Habitat suitability assessments conducted to date will inform future SRE surveys, further informing BHP Billiton Iron Ore’s knowledge of species potentially impacted by each development.

Table 28: Summary of potential level of impact to SRE habitat and priority for future management for each BHP Billiton Iron Ore tenement within the Project Definition Boundary

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
Caramulla						
100%	Yes	1-40%	Drainage foci and Swamp/ depressions (4)	*Med*	*Low*	All SRE habitats present extend well beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Groves and Drainage foci (3)	*Med*	*Low*	
			Dispersal habitats (2)	*Med*	*Low*	
			Unmapped area	*N/A*	*Low*	
Coondiner						
100%	No	0%	Deep gullies/ gorges (5)	*High*	*High*	The extensive Deep gullies/ gorges habitat, while continuous beyond the Full Conceptual Development Scenario, is still likely to record restricted fauna due to the high likelihood of isolated habitats. The Shallow gullies and Drainage foci habitat unit also appears to have limited extent beyond the Full Conceptual Development Scenario but the low suitability and similarity to other habitat reduce the likelihood. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Med*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	
Gurinbiddy						
100%	No	1-40%	Deep gullies/ gorges (5)	*High*	*High*	The Deep gullies/ gorges habitat in the western section appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Low*	

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Dispersal habitats and Swamp/ depressions (3)	*Low*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	
Jimblebar						
66.5%	Yes	60-80%	Deep gullies/ gorges (5)	*High*	*Med*	The Deep gullies/ gorges habitat in the north western section appears to be moderately impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and limited potential to become further isolated as a result of the Strategic Proposal. The remaining 18% of the Jimblebar tenure that is unmapped, which is impacted by the Full Conceptual Development Scenario, comprises some Phase 1 Level 5 suitability habitat, and therefore likely to contain High suitability habitat.
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*High*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*Low*	*Low*	
			Unmapped area	*N/A*	*High*	

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
Jinidi						
100%	Yes	40-60%	Deep gullies/ gorges (5)	*Low*	*High*	The Deep gullies/ gorges habitat in the north western section appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Boulders, Outcrops, Ridges and Breakaways (4)	*Med*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*Med*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*Low*	*Low*	
			Unmapped area	*N/A*	*Low*	
Marillana						
100%	No	1-40%	Deep gullies/ gorges (5)	*Med*	*Med*	The Isolated sands are heavily impacted and the Deep gullies/ gorges habitat in the south eastern section appears to be moderately impacted by the Full Conceptual Development Scenario, and the remaining Deep gullies/ gorge habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*Low*	*Low*	
			Isolated sands (4)	*High*	*High*	
			Groves and Drainage foci (3)	*High*	*Low*	

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	
Mindy						
100%	No	1-40%	Deep gullies/ gorges (5)	*High*	*High*	The Isolated sands and the Deep gullies/ gorges habitat are heavily impacted throughout the Mindy tenure. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Isolated sands (4)	*High*	*High*	
			Dispersal habitats and Swamp/ depressions (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	
Mining Area C						
100%	Yes	40-60%	Deep gullies/ gorges (5)	*Med*	*High*	The Deep gullies/ gorges habitat in the eastern section appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*Med*	*Low*	
			Groves and Outcrops (4)	*None*	*Low*	

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Dispersal habitats and Swamp/ depressions (3)	*Low*	*Low*	
			Groves and Drainage foci (3)	*Med*	*Low*	
			Shallow gullies and Drainage foci (3)	*Med*	*Low*	
			Dispersal habitats (2)	*None*	*None*	
			Unmapped area	*N/A*	*Low*	
Ministers North						
27.6%	No	0%	Drainage foci and Swamp/ depressions (4)	*None*	*None*	Only 24% of the Ministers North tenure is mapped with the remaining 76% comprising Phase 1 Level 5 suitability. As such, there is a high likelihood that this Operation Tenure may contain High suitability habitat.
			Dispersal habitats and Swamp/ depressions (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*High*	
Mudlark						
100%	Yes	1-40%	Deep gullies/ gorges (5)	*Med*	*High*	The Deep gullies/ gorges habitat in the northern and southern section's appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the
			Boulders, Outcrops, Ridges and Breakaways (4)	*Med*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*Low*	*Low*	

% Mapped	SRE Fauna Records	Survey Coverage[1]	SRE Habitat (Suitability)	Potential Level of Impact[2]	Potential Priority for Future Management[3]	Explanatory Notes
			Groves and Outcrops (4)	*Med*	*Low*	Strategic Proposal.
			Dispersal habitats and Swamp/ depressions (3)	*Low*	*Low*	
			Groves and Drainage foci (3)	*Low*	*Low*	
			Shallow gullies and Drainage foci (3)	*Med*	*Low*	
			Dispersal habitats (2)	*Low*	*Low*	
			Unmapped area	*N/A*	*Low*	
Munjina/ Upper Marillana						
100%	Yes	1-40%	Deep gullies/ gorges (5)	*None*	*None*	The most suitable SRE habitat in the Munjina/ Upper Marillana tenure (Level 4: Drainage foci and Swamp/ depressions) is extensive beyond the Full Conceptual Development Scenario and highly likely to occur well beyond the Operation Tenure boundary.
			Boulders, Outcrops, Ridges and Breakaways (4)	*None*	*None*	
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*Med*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*Low*	*Low*	
			Dispersal habitats (2)	*Med*	*Low*	
			Unmapped area	*N/A*	*N/A*	

<table>
<tr><th>% Mapped</th><th>SRE fauna records</th><th>Survey coverage[1]</th><th>SRE habitat (suitability)</th><th>Potential level of impact[2]</th><th>Potential Priority for Future Management[3]</th><th>Explanatory notes</th></tr>
<tr><td colspan="7">Newman</td></tr>
<tr><td rowspan="8">88.7%</td><td rowspan="8">Yes</td><td rowspan="8">40-60%</td><td>Deep gullies/ gorges (5)</td><td>High</td><td>High</td><td rowspan="8">The Deep gullies/ gorges habitat in the northern and south western sections appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The Boulders, Outcrops, Ridges and Breakaways in the south western section is also moderately impacted. The remaining mapped SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.

The remaining 21% of the Newman tenure that is unmapped, which is impacted by the Full Conceptual Development Scenario, is primarily Phase 1 Level 5 suitability habitat, and therefore likely to contain High suitability habitat.</td></tr>
<tr><td>Boulders, Outcrops, Ridges and Breakaways (4)</td><td>High</td><td>Med</td></tr>
<tr><td>Drainage foci and Swamp/ depressions (4)</td><td>Med</td><td>Low</td></tr>
<tr><td>Dispersal habitats and Swamp/ depressions (3)</td><td>High</td><td>Low</td></tr>
<tr><td>Groves and Drainage foci (3)</td><td>High</td><td>Low</td></tr>
<tr><td>Shallow gullies and Drainage foci (3)</td><td>Med</td><td>Low</td></tr>
<tr><td>Dispersal habitats (2)</td><td>Med</td><td>Low</td></tr>
<tr><td>Unmapped area</td><td>N/A</td><td>High</td></tr>
<tr><td colspan="7">Ophthalmia/Prairie Downs</td></tr>
<tr><td rowspan="5">84.7%</td><td rowspan="5">No</td><td rowspan="5">0%</td><td>Deep gullies/ gorges (5)</td><td>Med</td><td>Med</td><td rowspan="5">The Deep gullies/ gorges habitat appears to be lightly impacted by the Full Conceptual Development Scenario. The remaining mapped SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.

The remaining 25% of the Ophthalmia/Prairie Downs tenure that is unmapped, which is impacted by the Full Conceptual Development Scenario, is primarily Phase 1 Level 5 suitability habitat, and therefore likely to contain</td></tr>
<tr><td>Boulders, Outcrops, Ridges and Breakaways (4)</td><td>High</td><td>Low</td></tr>
<tr><td>Drainage foci and Swamp/ depressions (4)</td><td>Med</td><td>Low</td></tr>
<tr><td>Dispersal habitats and Swamp/ depressions (3)</td><td>Med</td><td>Low</td></tr>
<tr><td>Groves and Drainage foci (3)</td><td>Med</td><td>Low</td></tr>
</table>

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Shallow gullies and Drainage foci (3)	*Med*	*Low*	High suitability habitat.
			Dispersal habitats (2)	*Low*	*Low*	
			Unmapped area	*N/A*	*High*	
Rocklea						
0%	No	1-40%	Unmapped area	*N/A*	*High*	No mapping or survey work has been undertaken in this tenure and the Full Conceptual Development Scenario primarily impacts on Phase 1 Level 5 suitability. As such, there is a high likelihood that the Rocklea tenure may contain High suitability habitat.
Roy Hill						
10.9%	Yes	1-40%	Deep gullies/ gorges (5)	*Med*	*Med*	Only 10% of the Roy Hill tenure is mapped with the remaining 90% comprising approximately equal parts Phase 1 Level 5 and Level 3 suitability. As such, there is a high likelihood that this Operation Tenure may contain High suitability habitat.
			Boulders, Outcrops, Ridges and Breakaways (4)	*Med*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*High*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*High*	
South Flank						
100%	Yes	40-60%	Deep gullies/ gorges (5)	*High*	*High*	The Deep gullies/ gorges habitat in the central section

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Boulders, Outcrops, Ridges and Breakaways (4)	*Med*	*Low*	appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Groves and Outcrops (4)	*High*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*High*	*Low*	
			Groves and Drainage foci (3)	*High*	*Low*	
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*N/A*	
Tandanya						
100%	Yes	1-40%	Deep gullies/ gorges (5)	*High*	*High*	The Deep gullies/ gorges habitat in the northern sections appears to be heavily impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The Boulders, Outcrops, Ridges and Breakaways in the northern section is also moderately impacted. The remaining mapped SRE habitats extend beyond the Full Conceptual Development Scenario and have limited potential to become further isolated as a result of the Strategic Proposal.
			Boulders, Outcrops, Ridges and Breakaways (4)	*High*	*Med*	
			Drainage foci and Swamp/ depressions (4)	*High*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*Low*	*Low*	
			Groves and Drainage foci (3)	*Med*	*Low*	

% Mapped	SRE fauna records	Survey coverage[1]	SRE habitat (suitability)	Potential level of impact[2]	Potential Priority for Future Management[3]	Explanatory notes
			Shallow gullies and Drainage foci (3)	*High*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	
Yandi						
98%	Yes	>80%	Deep gullies/ gorges (5)	*High*	*Med*	The small amount of Deep gullies/ gorges habitat in the western and eastern sections appears to be moderately impacted by the Full Conceptual Development Scenario, and the remaining habitat is likely to contain isolated habitats. The remaining SRE habitats extend beyond the Full Conceptual Development Scenario and have limited isolation potential.
			Boulders, Outcrops, Ridges and Breakaways (4)	*Low*	*Low*	
			Drainage foci and Swamp/ depressions (4)	*Med*	*Low*	
			Dispersal habitats and Swamp/ depressions (3)	*Med*	*Low*	
			Groves and Drainage foci (3)	*Med*	*Low*	
			Shallow gullies and Drainage foci (3)	*Low*	*Low*	
			Dispersal habitats (2)	*High*	*Low*	
			Unmapped area	*N/A*	*Low*	

1. Survey coverage refers to the proportion of the area that has been surveyed for SREs
2. The potential level of impact has been determined based on the approximate level of impact to mining-operation tenure, given the proportion of each SRE habitat within the Project Definition Boundary. The process for determining level of impact is detailed in Appendix 5.
3. This gives an indication of the potential priority level for each SRE habitat, taking into account the factors mentioned above and within the context of the proportion of mapping that has been completed.

8.1.5 SUBTERRANEAN FAUNA ASSESSMENT

8.1.5.1 EXISTING ENVIRONMENT

Subterranean fauna are categorised as either stygofauna or troglofauna. Stygofauna are aquatic and inhabit vugs, fissures and other spaces in groundwater aquifers, whereas troglofauna are air-breathing and inhabit similar spaces in the unsaturated zone.

BHP Billiton Iron Ore engaged Bennelongia to collate existing survey data on subterranean fauna in the Pilbara to determine known distribution and potential habitat in the form of suitability maps (Appendix 6). Two geographic levels of data analysis were undertaken. First, the subterranean fauna values of the whole Pilbara region were analysed, then more detailed analyses were undertaken in the broad area of the Strategic Proposal. This area approximately covers existing and proposed mines from the western edge of Karijini National Park in the central Pilbara to east of Newman.

Stygofauna

A Pilbara-wide survey conducted by Halse et al. (2014) showed that areas containing rich stygofauna communities occur across most of the Pilbara. Using these data and other sampling results, 12 focal sites with a high richness of stygofauna were identified in seven areas within or adjacent to the broad area of the Strategic Proposal. These focal sites were near Paraburdoo, southwest of Tom Price, Ethel Gorge, Upper Weeli Wolli and Coondewanna creeks, Weelumurra Creek, northern and eastern Fortescue Marsh and Mulga Downs. In addition to being a focal site, Ethel Gorge supports a stygofaunal TEC; and Weeli Wolli Spring within the Upper Weeli Wolli Catchment is listed as a PEC, partly because of stygofaunal values (Bennelongia 2015).

Within the Project Definition Boundary, stygofauna richness is highest in aquifers within the Quaternary and Tertiary valley-fill deposits in palaeovalleys and modern river channels (Appendix 6) that cover a substantial part of the Pilbara both within and outside of the Project Definition Boundary. These aquifers have numerous voids and spaces that provide prospective stygofauna habitat, and most have shallow water tables.

There have been few attempts to define the ranges of stygofauna species in the Pilbara or the factors affecting these ranges. Studies (to date) indicate that almost all stygofauna of the Pilbara are endemic to the region. There is variation among groups of stygofauna in the proportion of species with small ranges. Ostracods, syncarids, isopods and, probably, amphipods are dominated by species with small ranges. Many species in other groups will also have small ranges. There is little quantitative information on the ranges of stygofauna species, but it has been suggested that half the species considered to be 'locally' restricted will have ranges less than 700 km^2 (Bennelongia 2015). More detailed information about the ranges of species in the major stygofauna groups occurring in the Pilbara is summarised in (Appendix 6).

Troglofauna

No regional survey of troglofauna has been undertaken in the Pilbara, but information derived from environmental impact assessments for mining developments, primarily for iron ore, suggests that diplurans are the most speciose group (76 species), followed by isopods (54 species), beetles (54 species), pseudoscorpions (49 species) and schizomids (47 species). Many other groups are also represented by large numbers of species (Halse & Pearson 2014).

Bennelongia identified 17 focal sites in the Pilbara where drill holes yielded more than four species per sample, all of which were associated with iron ore projects (Appendix 6). While sampling elsewhere has recorded some troglofauna outside mineralised iron formations in the Pilbara, it is not known whether these specimens belong to significant troglofauna communities or represent isolated species occurrences in communities with low species numbers or diversity. Intensive sampling of a range of geologies would be required to establish the relative importance of other geologies in the Pilbara compared with iron formations.

Eight of the 17 troglofauna focal sites identified on the basis of sample richness are located within the broad area of the Strategic Proposal. Examination of troglofauna survey data in the Western Australia Museum's database and in available assessment reports identified four additional community-based focal sites with greater than 15 species in each community. These focal sites (perhaps better considered as focal areas) are located in the Weelumurra Creek valley in the central Hamersley Range (Subterranean Ecology 2010;

Bennelongia 2011b) (two focal sites), eastern Chichester Range on the flanks of the Fortescue Valley (Bennelongia 2011a) and at Koodaideri in the eastern Hamersley Range.

Based on global literature and existing information from the Pilbara, it may be generalised that troglobites (restricted to below-ground habitats throughout their life), usually have smaller ranges than their troglophilic (living below ground but with a short life stage or some populations on the surface) counterparts, which have greater dispersal capacity. Trogloxenes (animals that use caves or other underground habitats for shelter) have ranges with the characteristics of surface species and so are usually relatively widespread.

Nearly all troglofauna species in the Pilbara are undescribed; and identification issues, as well as sampling biases, often lead to species' ranges being underestimated. For example, when wide-ranging undescribed species are collected in different assessment surveys by different companies, they are usually reported as a series of highly restricted species, each designated by different codes. The BHP Billiton Iron Ore–supported WAMinals Project aims to address this issue (refer to Section 8.1.5.3).

8.1.5.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara that are relevant to subterranean fauna, and the potential impacts to biodiversity linked to these activities, are listed in Table 29. A brief description of each potential impact is provided.

Table 29: Potential threats to subterranean fauna from mining activities

POTENTIAL THREAT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Mining operations (direct impact)	Mining operations impact directly on subterranean fauna by removing geological types that provide habitat to these species during the mining process. Impacts from removal of habitat during mining are discussed in Section 8.1.5.4.
Groundwater alteration (direct impact to stygofauna and indirect impact to troglofauna)	Groundwater can be abstracted to allow mining of deposits that occur below the groundwater level. Some of this water can be used during the mining process, while excess water is typically managed by reinjection, surface water discharge, and holding ponds and dams. These activities may directly impact stygofauna habitat, because these species are restricted to pore spaces below the water table. Impacts to stygofauna in prospective habitat are considered in Section 8.1.5.4. The impact of a lowered water table on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied, but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose zone is affected by depth to the water table is unclear. Given that pockets of residual water probably remain trapped throughout dewatered areas and keep the overlying substrate saturated with water vapour, dewatering may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall, dewatering outside the proposed mine pits is not considered to be a significant risk to troglofauna. It has also been observed that the quality of recharge water declines during and after mining operations as a result of rock break-up and soil disturbance (e.g. McAuley & Kozar 2006; Gajowiec 1993). Impacts can be minimised through management of surface water and installing drainage channels, sumps and pumps in the pit to prevent recharge though the pit floor. Potential impacts of hydrological change are further discussed in Section 8.2.
Vibration from blasting (indirect impact)	Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with

POTENTIAL THREAT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
	distance from the pit and are not considered to be a significant risk to either stygofauna or troglofauna outside the proposed mine pits. Blasting is not considered further within this impact assessment.
Presence of modified landforms (indirect impact)	Artificial landforms, such as OSAs and stockpiles, may cause localised reduction in rainfall recharge and associated inflow of dissolved organic matter and nutrients because water runs off these landforms rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy (obtaining energy from electrons in their environment) in driving the subterranean system compared with infiltration-transported surface energy and nutrients. These landforms are unlikely to cause species extinctions, although population densities of species may decrease under them. Given the low risk associated with this threat, presence of modified landforms is not considered further within this impact assessment.
Contamination of soils and water (indirect impact)	Any contamination is likely to be localised and may be minimised by engineering and management practices to ensure the containment of hydrocarbon products. This potential threat is not considered further within this impact assessment.

8.1.5.3 MITIGATION

BHP Billiton Iron Ore will apply mitigation measures from the Land and Biodiversity Management toolkit (Figure 17) to manage impacts to subterranean fauna. A summary of management actions routinely used by BHP Billiton Iron Ore to mitigate the threatening processes identified in Section 8.1.5.2 is provided in Table 30. Specific examples of the mitigation toolkit being implemented in existing and proposed operations are provided below.

Table 30: Potential management approaches for subterranean fauna

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Mining operations (direct impact)	• *Avoidance through informed design* by confining the mine pit to the smallest possible area and, when mining below the water table, using dewatering strategies to minimise the area experiencing any reduction in watertable level. • *Avoidance* or *minimisation through informed design* by avoiding or minimising clearing of subterranean fauna habitat for conservation-significant species through undertaking *baseline surveys* and, where practicable, altering mine plans to avoid significant habitats. • Avoid unauthorised clearing through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • *Rehabilitate* cleared areas, progressively where possible. Consider or develop rehabilitation practices that include suitable approaches for subterranean *fauna habitat creation* where appropriate.
Groundwater alteration (direct impact – stygofauna) (indirect impact – troglofauna)	• Undertake appropriate *groundwater management* to avoid significant impacts to areas with high subterranean fauna value (refer to Section 8.2.2.3, Hydrological Processes and Inland Waters Environmental Quality Assessment). • Undertake *ecological asset monitoring* where appropriate for areas with high subterranean fauna values.
Vibration from blasting (indirect impact)	Low risk to subterranean fauna; management actions not applicable.
Presence of modified landforms (indirect impact)	Low risk to subterranean fauna; management actions not applicable.

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Contamination of soils and water (indirect impact)	Low risk to subterranean fauna; management actions not applicable.

1 Management approaches are indicative and are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

Baseline Surveys and Research

BHP Billiton Iron Ore undertakes subterranean fauna baseline surveys using bore holes from exploration drilling across areas considered to be prospective for subterranean fauna in accordance with Environmental Assessment Guideline 12: Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia (EPA 2013). Prospectivity is determined through geological type and presence of pores within the geological types. Depth to groundwater is also an important factor for stygofauna prospectivity.

Case Study 5 provides an example of the work BHP Billiton Iron Ore has participated in to assist with taxonomic identification of troglofauna species.

Case Study 5: Collaboration with the Western Australian Museum to identify troglofauna consistently

With different environmental consultants working for different companies across different areas of the Pilbara and the state, troglofauna collected in each survey tend to be treated as unique and given different names and classifications by each consultant. This has made it difficult to use this data effectively in environmental impact assessment and conservation management.

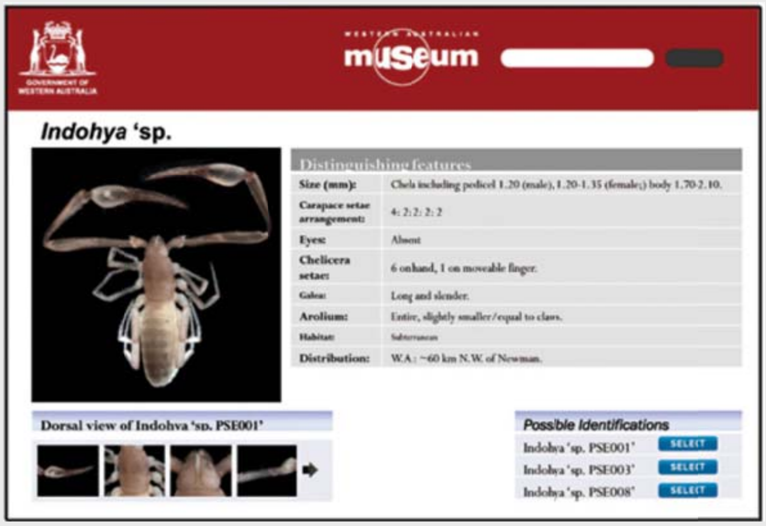


Photo: BHP Billiton Iron Ore.

Catalogued troglofauna on the online resource WAMinals

In 2011, BHP Billiton Iron Ore set up a pilot project in partnership with environmental consultants Bennelongia and the Western Australian Museum to describe, photograph or sketch and provide diagnostic characteristics on 120 troglofauna species, including longitude and latitude data.

Samples were cross-referenced against other locations where the animal had been recorded. The information was uploaded to the Western Australian Museum's online field guides and catalogues resource, WAMinals, which is available to other companies.

The formal naming process, on a scale required for the subterranean fauna of the Pilbara, posed a difficult challenge. It was decided with the Western Australian Museum that the cataloguing system and website provided a useful starting point.

While not a formal taxonomic 'key', WAMinals provides information to at least allow species to be matched. This system has the ability to grow as it is collaborative and beneficial to everyone in the industry and broader community. As a resources industry leader and major presence in the Pilbara , BHP Billiton Iron Ore has taken responsibility for establishing this important work.

Avoidance through informed design

In a vast majority of cases, BHP Billiton Iron Ore has been able to undertake baseline surveys to demonstrate that subterranean fauna species found within pit areas also occur outside of pit areas. Where BHP Billiton Iron Ore cannot demonstrate that this is the case, avoidance of important subterranean fauna populations or habitat through mine planning and design may be required. For example, pit shells may be modified to avoid impacts to areas identified as having high subterranean fauna value while further survey work is undertaken to identify species outside of impact areas.

The Derived Proposal process allows this validation work to be done in conjunction with the detailed mine planning and design to ensure that the implementation of the Strategic Proposal meets the EPA's objective for subterranean fauna.

Dewatering activities can often be managed to minimise impacts to subterranean fauna habitat, particularly stygofauna habitat. Groundwater management is discussed in Section 8.2.

8.1.5.4 SIGNIFICANCE OF IMPACTS

The primary basis for the EPA's determination of the likely significance and acceptability of a proposal is whether it is likely to meet the EPA's objectives for each environmental factor. The EPA uses a significance framework to determine the likely significance of a proposal and to make decisions throughout the environmental impact assessment process, as outlined in EPA Environmental Assessment Guideline No. 9 (EPA 2015b). If the EPA considers that a proposal can meet all of its objectives, then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives, its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives, then its effect on the environment is likely to be unacceptable.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework to determine whether the proposal can meet the EPA objectives for each environmental factor. For the purposes of evaluating significance, the extent of subterranean fauna prospectivity mapping was used as a basis for a quantitative impact assessment. The results are discussed below.

Impact to Stygofauna

Results of the Halse et al. (2014) survey indicate that only low numbers of stygofauna occur where depth to groundwater is greater than 30 m. Groundwater levels as described in Section 8.2 were used to predict existing prospective stygofauna habitat and changes to prospective habitat based on development scenarios.

In identifying prospective habitat, Bennelongia considered areas with depth to groundwater of less than 40 m to provide a conservative approach (Appendix 6). Groundwater levels were also used to predict where few stygofauna would occur, irrespective of geology, because the water table is too far below the surface. Areas of prospective stygofauna habitat were ranked as either Low or High based on whether the depth to groundwater was greater or less than 40 m. Prospective stygofauna habitat, using this method, is shown in Figure 34. It should be noted that prospectivity mapping for stygofauna was based on the modelled depth to groundwater and, because of the coarse scale of the mapping, that the location of all prospective stygofauna habitats may not be identified.

As Figure 34 shows, areas with depth to groundwater less than 40 m (usually in palaeovalleys) occur within or close to the 30% Conceptual Development Scenario and Full Conceptual Development Scenario for the Strategic Proposal. Furthermore, some proposed operations may result in medium to high groundwater change potential in areas of high prospectivity. Strategic Proposal tenure in which both high prospectivity habitats and medium to high groundwater change potential occur are predicted to be Tandanya, Mudlark, Jinidi, Newman, Jimblebar, Carramulla, Coondiner, Mindy and Marillana.

As outlined in Appendix 6, the Pilbara supports more than 500 species of stygofauna and is a globally important area for this type of animal. The number of stygofauna species that may potentially be affected by development is likely to increase at a greater rate than the overall increase in areas of impacted High prospectivity habitat. As individual impacted areas become larger, they exceed the ranges of an increasing number of species, and the potential threat to stygofauna conservation values grows.

Data in Eberhard et al. (2009) suggest that about 60% of stygofauna species in the Pilbara have locally restricted distributions (known from single subbasins, such as the middle Fortescue), and Halse et al. (2014) suggested the median range of such species is less than 700 km^2. Thus, it is likely that about 30% of stygofauna species have ranges that are small enough to be affected by impacts approaching 30 km in linear extent if the species' distribution and impacts coincide. In most situations, the factors controlling species' distributions and impacts will be different so that relatively few species distributions are likely to be completely encompassed by impacted areas.

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact stygofauna habitat of high prospectivity through mining and groundwater drawdown and that these areas will require considered management using the Land and Biodiversity Management toolkit (refer to Figure 17) to ensure that the objectives for subterranean fauna are met. The Derived Proposal process (as outlined in Section 4.2.3 and Chapter 11) allows validation of prospective stygofauna habitat as further surveys are conducted and more information is gathered about habitat requirements for stygofauna and detailed mine design and engineering is determined. For these reasons, BHP Billiton Iron Ore considers that impacts to stygofauna can be managed to an acceptable level.

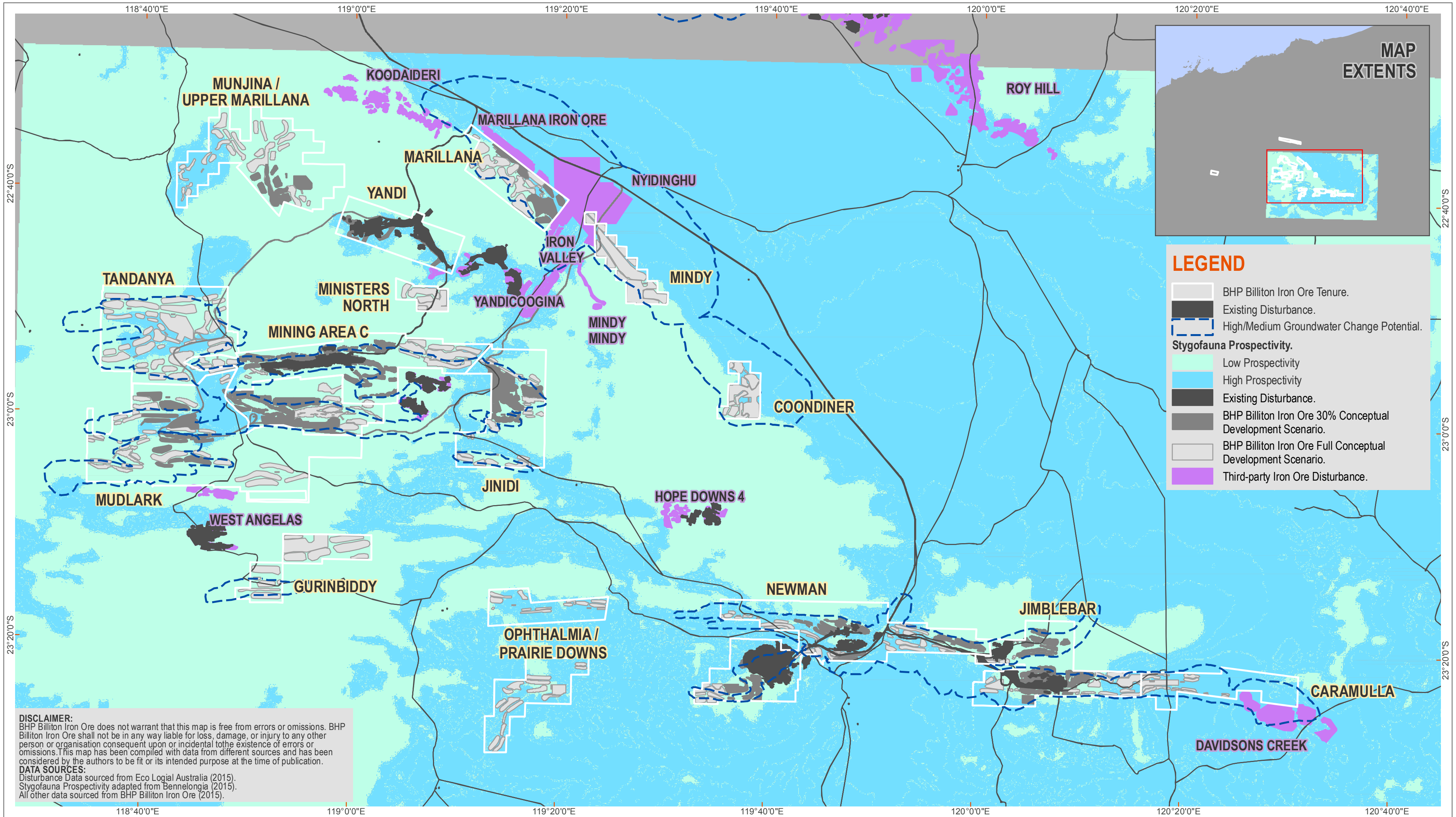
Impact to Troglofauna

Current troglofauna data from areas sampled suggest that rich troglofauna communities occur in mineralised geologies on the flanks of valleys, as well as in the adjacent footslopes where mineralised geologies may be overlain by colluvium and the surrounding ridges and plateaux where hardcap is often well developed.

Areas likely to be prospective for troglofauna within the Strategic Proposal area and wider Pilbara region were determined by using contour maps to identify valley flanks and mesas. All areas with a slope greater than 11.6° were considered to contain valley flanks, mesas or other features likely to support troglofauna. It should be noted that this is an investigative method of identifying areas of likely troglofauna occurrence. Figure 35 shows the troglofauna prospectivity mapping in relation to the development scenarios.

The mapping highlights the Hamersley Range as being likely to contain the richest troglofauna communities in the Pilbara, which existing information suggests is correct (Appendix 6). Furthermore, all focal areas identified from the Pilbara biodiversity survey sampling results, other than Cloudbreak, would be inferred from the mapping to have rich troglofauna communities. Almost all Strategic Proposal tenure overlaps with areas that are predicted to be of high prospectivity for troglofauna. The exceptions are Jimblebar, Caramulla, Ophthalmia/Prairie Downs and Roy Hill.

In many cases, parts of the mapped impacted area associated with a mining operation will have more likelihood of troglofauna occurrence than suggested by prospectivity analysis. For example, a valley slope associated with an ore deposit may have a slope identifying it as prospective habitat, but the adjacent plateau containing weathered ore and hard cap may not. It is also likely that some areas of channel iron deposit and detrital iron deposit that support troglofauna will not be identified as high prospectivity and some areas of small, low pisolitic hills that support troglofauna may not be identified as high prospectivity unless mapping is undertaken at a very fine scale (Appendix 6).



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Strategic Proposal

Figure 34 Stygofauna prospectivity and the development scenarios

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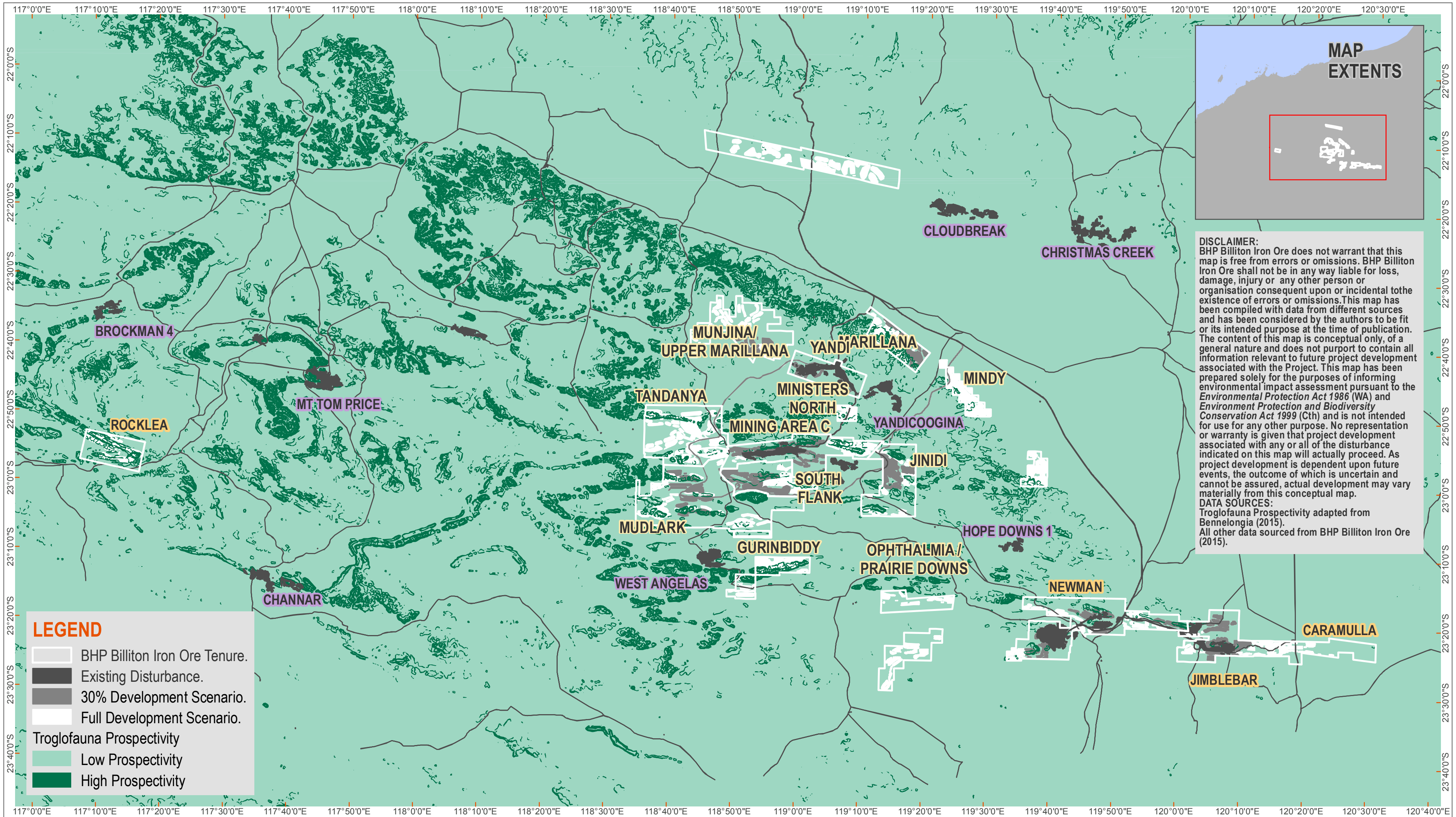

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Figure 35a Troglofauna prospectivity and conceptual development scenarios (overview)

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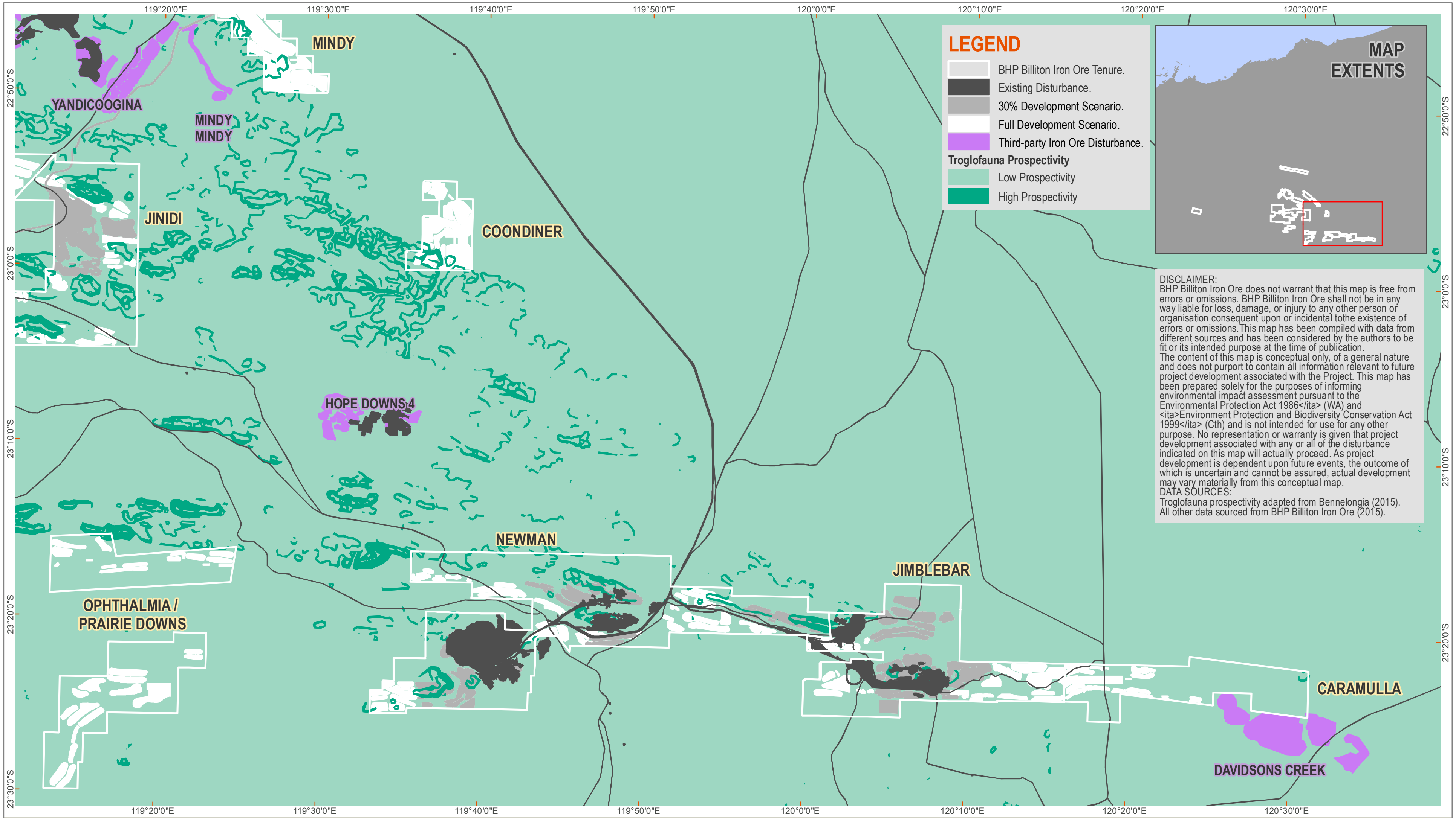

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Figure 35b Troglofauna prospectivity and conceptual development scenarios (east)

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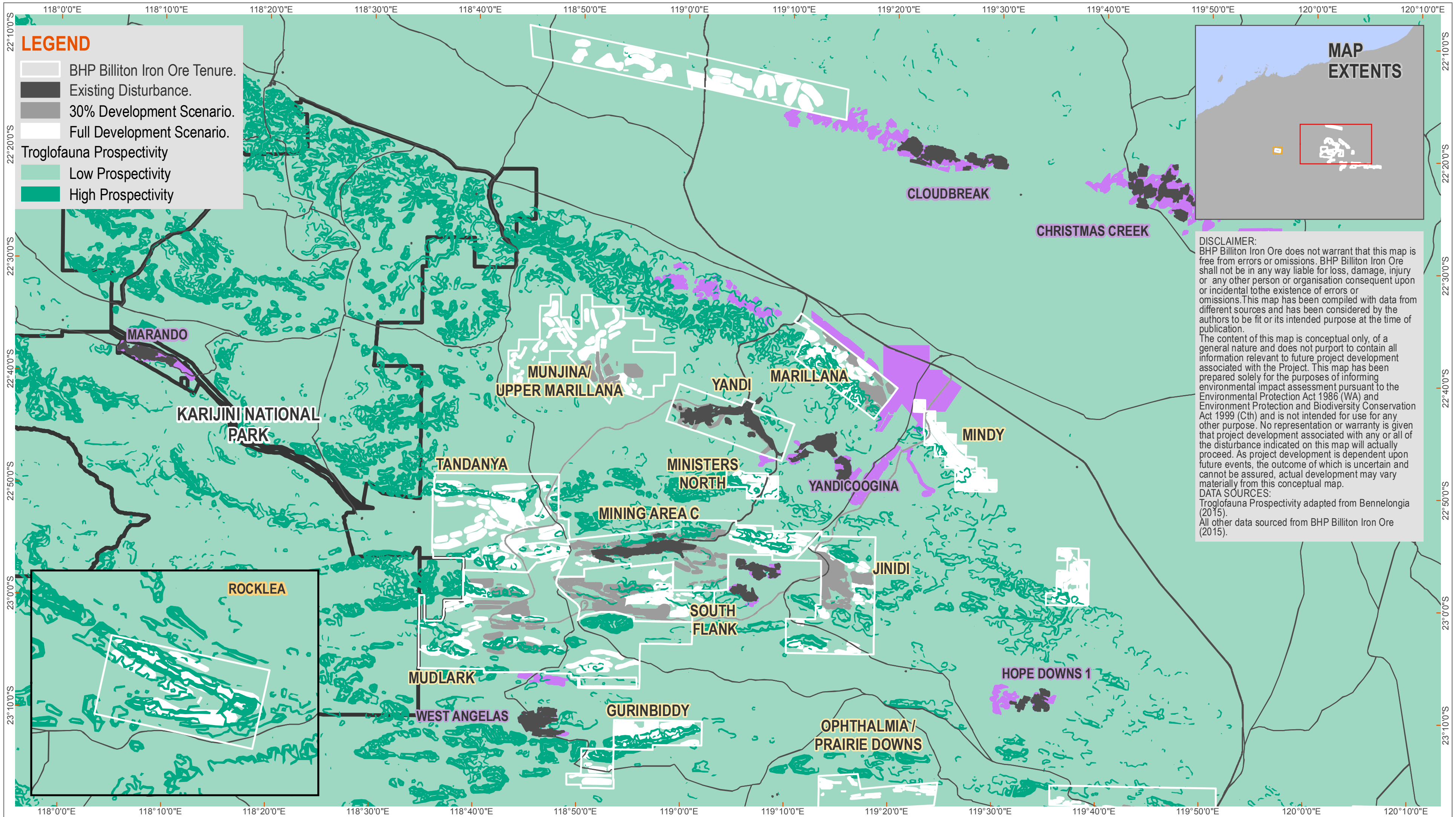

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Strategic Proposal

Figure 35c Troglofauna prospectivity and conceptual development scenarios (overview)

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As outlined in Appendix 6 (and references therein), sampling by Bennelongia has recorded more than 566 species of troglofauna in the Pilbara, and many additional species have been collected in other surveys. Individual pits within a mine may exceed 5 km^2, and Halse & Pearson (2014) showed that even 5 km^2 would encompass the known median range of troglofaunal schizomid species, spider species, harvestman species and isopod species. All groups of troglofauna have some species with known ranges of about 1 km^2, although for many species this is probably an underestimate of their true range. The factors controlling species' distributions and impacts may be different, so that relatively few species distributions are likely to be completely encompassed by the mine pits.

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact troglofauna habitat of high prospectivity through its activities and that these areas will require considered management using the Land and Biodiversity Management toolkit (refer to Figure 17) to ensure that the objectives for subterranean fauna are met. The Derived Proposal process (as outlined in Section 4.2.3 and Chapter 11) will allow BHP Billiton Iron Ore to validate the potential threats to subterranean fauna at a site level as mine planning and engineering designs are confirmed. For these reasons, BHP Billiton Iron Ore considers that impacts to troglofauna can be managed to an acceptable level.

8.1.6 LANDFORMS AND TERRESTRIAL ENVIRONMENTAL QUALITY ASSESSMENT

8.1.6.1 EXISTING ENVIRONMENT

Terrestrial environmental quality influences all aspects of the environment, including its ecological and social values (EPA 2015d) and includes the interaction of soils, climate, landforms, geochemistry, flora and vegetation, and fauna with landscape and geology. Landforms are the result of the surface expressions of geological material being exposed to climate over periods of time. The nature and composition of the geological material dictates the manner in which it will be shaped by erosive forcing, resulting in a particular type of landform. The existing environment for terrestrial environmental quality and landforms is discussed below.

Landforms in the Pilbara Landscape

The Pilbara landscape is variable and shaped by the structure of the underlying geology, with moderately high relief and a number of ranges, river valleys and peneplains (van Vreeswyk et al. 2004). The more resistant banded ironstone formations outcrop in mountainous areas and local peaks, whereas the less-resistant formations associated with the Paraburdoo Member of the Wittenoom Formation have been extensively weathered to underlie the broad valley floors. The Marra Mamba Iron Formation also occurs in topographic lows associated with the dolomites and overlain by alluvial sediments in many areas. A conceptual cross-section of the geology and corresponding landforms in the Pilbara is shown in Figure 36.

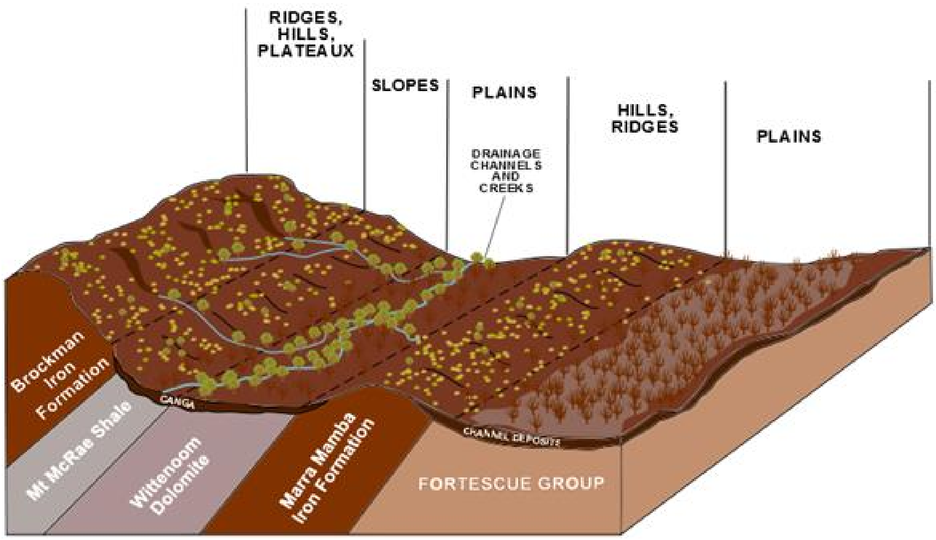


Figure 36: Conceptual cross-section of geology and corresponding landforms contributing to the Pilbara landscape

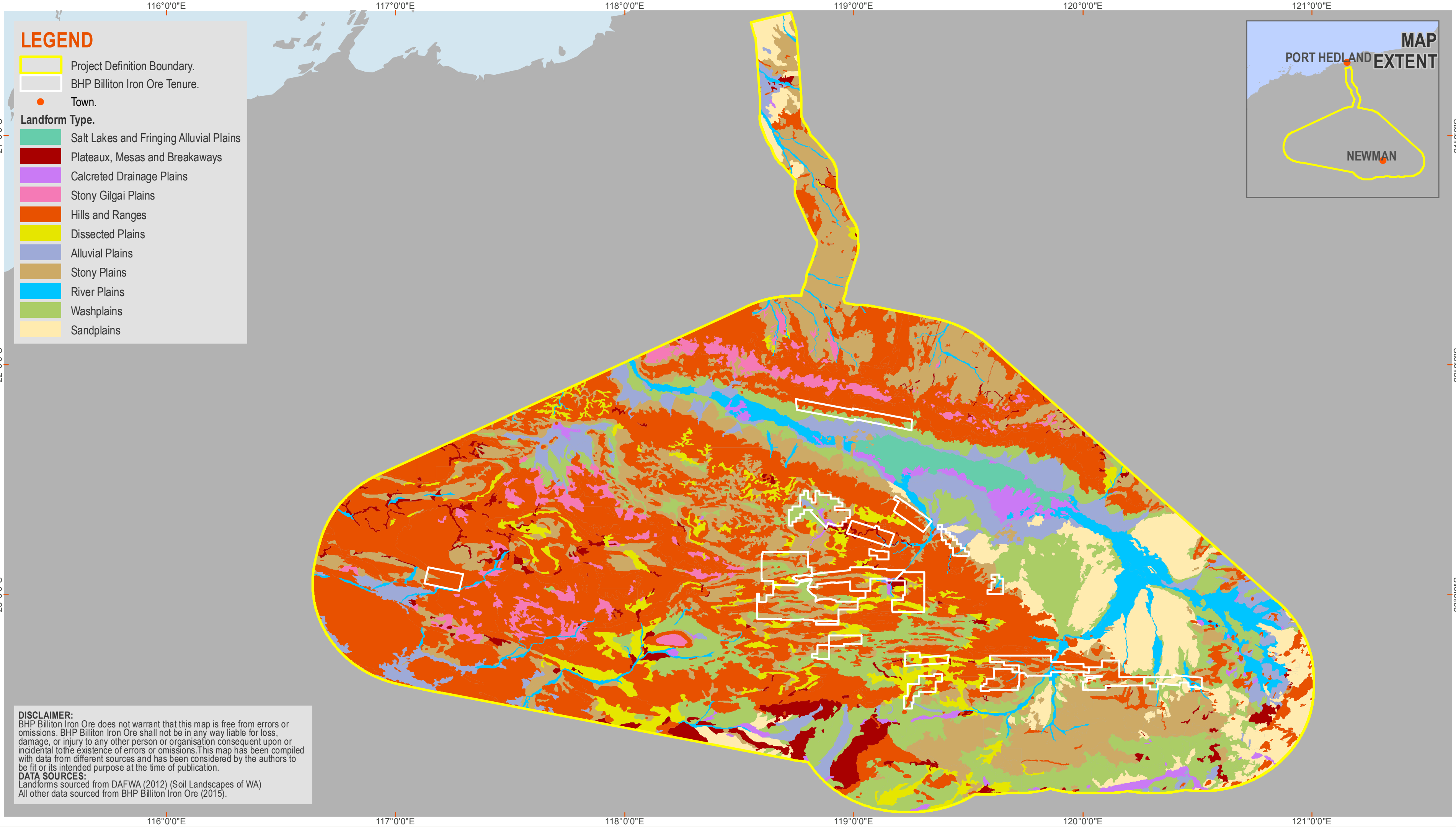
The most common landform type within the Project Definition Boundary is hills and ranges, followed by stony plains and washplains (Table 31). The spatial distribution of these dominant landform types across the Project Definition Boundary is shown in Figure 37.

Table 31: Landform types and their representation within the Project Definition Boundary

Dominant Landform Types	Land Systems within Project Definition Boundary	Total % Pre-European Extent Remaining	% of Land System within the Project Definition Boundary
Hills and Ranges	Augustus, Black, Boolaloo, Capricorn, Charley, Granitic, Kooline, Marandoo, McKay, Newman, Robertson, Rocklea, Ruth, Talga and Mulgul Systems	99.71%	39.26%
Stony Plains	Adrian, Bonney, Boolgeeda, Collier, Dollar, Elimunna, Ethel, Ford, Macroy, Nirran, Prairie, Satirist and Sylvania Systems	99.63%	18.58%
Washplains	Cadgie, Fan, Jamindie, Jurrawarrina, Nooingin, Pindering, Spearhole, Three Rivers, Wannamunna, Washplain and Zebra Systems	99.74%	13.50%
Sandplains	Buckshot, Divide, Little Sandy and Uaroo Systems	99.84%	7.07%
Alluvial Plains	Ashburton, Balfour, Brockman, Cheela, Christmas, Cowra, Cundelbar, Edward, Hooley, Mallina, Marillana, Narbung, Tallawuna, Turee and Urandy Systems	99.90%	5.62%
Dissected Plains	Billygoat, Egerton and Platform Systems	99.69%	4.20%
River Plains	Coolibah, Fortescue, Jigalong and River Systems	99.39%	4.04%
Plateaux, Mesas and Breakaways	Kumina, Kunderong, Laterite, Oakover, Robe, and Table Systems	99.33%	2.58%
Stony Gilgai Plains	Paraburdoo, White Springs and Wona Systems	99.87%	2.56%
Calcreted Drainage Plains	Calcrete and Warri Systems	99.93%	1.31%
Salt Lakes and Fringing Alluvial Plains	Marsh System	99.99%	1.28%

The Department of Agriculture (now the Department of Agriculture and Food) has conducted inventory and condition surveys of the Pilbara (van Vreeswyk et al. 2004) using an integrated survey method involving the land system approach to rangeland description and evaluation. The primary objectives of the surveys were to provide comprehensive descriptions and mapping of the biophysical resources of the region and to evaluate the condition of soils and vegetation. The mapping is based on patterns in topography, soils and vegetation.

Seventy-seven land systems occur within the Project Definition Boundary. The land systems found within the Project Definition Boundary are predominantly intact, with all land systems having more than 95% of their pre-European extents remaining within the state.



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Strategic Proposal

Figure 37 Landform types and their distribution across the Project Definition Boundary

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Physical Characteristics of Pilbara Geological Formations

The current soil-landscape of the Pilbara region can be traced back to its parent geologies. Through various physical, chemical and biological processes over an estimated 3.5 billion years, the region's geology has influenced all aspects of the existing environment, including its ecological, economic and resultant social values. Precambrian (the period from the formation of the Earth to approximately 540 million years ago) basement rocks, generated during phases of sedimentation, intrusion and volcanism are thought to have deformed and metamorphosed due to movements in the Earth's crust, resulting in most of the Pilbara's geologies being cut by intrusive dykes and veins. Subsequent erosion of these basement rocks and transportation by drainage channels has also led to the deposition of the Cenozoic (current geological era) surficial units (Johnson 2004).

The Hamersley Basin, consisting of the Hamersley and Turee Creek groups (the latter overlays the former), overlies the Precambrian basement rocks (Johnson 2004). The Hamersley Basin is overlain by the Fortescue Basin (Figure 38).

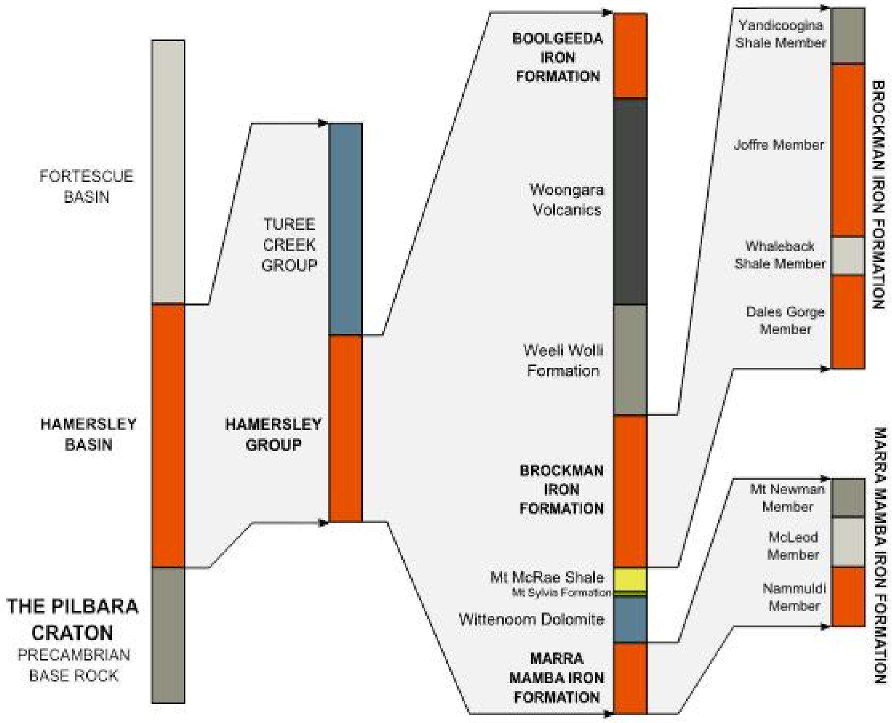


Figure 38: Stratification of the Hamersley Group

In places, iron enrichment of banded iron formations has formed orebodies within the Brockman Iron and Marra Mamba Iron formations, as well as iron-rich detrital sediments (e.g. the Boolgeeda Iron Formation and, to a lesser extent, the Weeli Wolli Formation, largely originating from the Marra Mamba Iron and Brockman Iron formations) that have accumulated in fluvial paleochannels, which are often mined as channel iron deposits.

Banded ironstone formation, the dominant rock type comprising the Brockman Iron and Marra Mamba Iron formations, is a sedimentary rock composed of iron and silica minerals in characteristic bands. While the majority of banded ironstone formation has low iron content, in places it has been enriched by the natural process of supergene enrichment to over 60% iron (Johnson & Wright 2001).

Two other types of iron ore deposit found in the region are pisolites and detritals. Flat-lying deposits of pisolitic limonite within the Robe Pisolite are found preserved as mesas and benches along former watercourses that drained the Hamersley Group. The pisolithic limonite possibly formed when humic, iron-rich solutions interacted with alluvium in low-energy, vegetation-rich river systems. These deposits have subsequently been exposed through weathering to form the channel iron ore detritus derived from erosion and weathering of the Brockman Iron and Marra Mamba Iron formations, as well as from reworking of channel deposits.

Geochemical Characteristics of Pilbara Geological Formations

Some geological types in the Pilbara contain pyritic material that can create acid metalliferrous drainage (AMD) if the material is brought to the surface during mining. A 1997 review of operating and historic mines in Australia with pyritic minerals present showed that the Pilbara region has relatively lower levels of occurrences than other mining regions in the state (e.g. Goldfields). Within the Pilbara, the presence of pyritic materials was generally restricted to the major river valleys, such as those associated with the De Grey and Fortescue rivers (DoEHP 1997).

BHP Billiton Iron Ore commissioned a number of studies into AMD and geochemical characteristics of comparable mining operations in the Pilbara region (Table 32). The Dales Gorge Member occurs in close proximity to the Mount McRae Shale, which has been found to contain potentially acid forming (PAF) material (Net Acid Producing Potential (NAPP) of greater than 3 kg H_2SO_4/t) (Earth Systems 2014a). Similarly, as the Marra Mamba Iron Formation lies below the Mount McRae Shale, there is the possibility of PAF material being encountered.

In general, PAF material is occasionally encountered in the Mount McRae Shale and less frequently in other lithological units. The table below generally categorises the AMD source risk for several BHP Billiton Iron Ore and third-party iron ore operations in the Project Definition Boundary based on AMD source potential. The table also summarises the target geologies, comparable Strategic Proposal operations (based on similar underlying geology) and references for the AMD source risk assessment.

Table 32: AMD source risk at BHP Billiton Iron Ore and other Pilbara mining operations

Mining Operation	Geological Formation	Comparable BHP Billiton Iron Ore Mining Operations	AMD Source Risk	References
BHP Billiton Iron Ore – Orebody 29, 30 and 35	Marra Mamba Iron Formation	Newman, Ophthalmia/ Prairie Downs	Low	SRK Consulting (2013a)
BHP Billiton Iron Ore – Orebody 19 and 31	Marra Mamba Iron Formation	Jimblebar, Caramulla	Low	Earth Systems (2014a; 2014b)
BHP Billiton Iron Ore – Orebody 25W and 32E	Brockman Iron Formation, Marra Mamba Iron Formation	NA	Low	SRK Consulting (2015)
BHP Billiton Iron Ore – Orebody 17 and 18	Brockman Iron Formation	NA	Low to moderate	Earth Systems (2015)
BHP Billiton Iron Ore – Orebody 23 and 25	Brockman Iron Formation	NA	Low to moderate	SRK Consulting (2013b)
BHP Billiton Iron Ore – Yandi Operations	Channel iron deposits	NA	Low	GHD (2014)
BHP Billiton Iron Ore – Mining Area C	Brockman Iron Formation, Marra Mamba Iron Formation	NA	Low to moderate	KCB (2014)
BHP Billiton Iron Ore – Goldsworthy North Area	Nimingarra Iron Formation	NA	Low to moderate	Golder (2013)
BHP Billiton Iron Ore – South Jimblebar, Hashimoto and Wheelarra Hill Deposits	Brockman Iron Formation, Marra Mamba Iron Formation	NA	Low to moderate	ERM (2012)

MINING OPERATION	GEOLOGICAL FORMATION	COMPARABLE BHP BILLITON IRON ORE MINING OPERATIONS	AMD SOURCE RISK	REFERENCES
BHP Billiton Iron Ore – Orebody 24 and 25	Brockman Iron Formation	NA	Low to moderate	BHP Billiton Iron Ore (2010)
Robe River Associates – West Angelas Iron Ore Project	Brockman Iron Formation, Boolgeeda Iron Formation	Mudlark, Tandanya, Gurinbiddy	87% NAF (non-acid-forming), 11% uncertain, 7% PAF	Robe River Mining Co (2015)
Rio Tinto Iron Ore – Yandicoogina	Alluvial channel iron deposits, Weeli Wolli Formation	Munjina/Upper Marillana	NAF	Rio Tinto Iron Ore (2015)
Rio Tinto Iron Ore – Koodaideri Iron Ore Project	Brockman Iron Formation	Marillana, Mindy, Coondiner	NAF	Rio Tinto Iron Ore (2013)
Fortescue Metals Group – Christmas Creek Deposit	Marra Mamba Iron Formation	Roy Hill Mining Operation	NAF[1]	Graeme Campbell and Associates (2005)
API Management - West Pilbara Iron Ore (Hardey) Project	Brockman Iron Formation, Marra Mamba Iron Formation	Rocklea	NAF	API (2012)

1. Some PAF black-shales were noted, however mining was not expected to be deep enough to intersect them

8.1.6.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara relevant to source of impact to landforms and terrestrial environmental quality and the potential impacts linked to these activities are listed in Table 33. A brief description of each potential impact is also provided.

Table 33: BHP Billiton Iron Ore's activities and potential impacts to environmental quality and landforms

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Permanent modification of landforms	The construction and operation of open-cut mines and the associated infrastructure can result in the permanent modification of landforms, for example, the removal of a ridgeline, the creation of mine voids, or the addition of an overburden storage area. The extraction of ore from target landforms results in a reduction in total landform area across the Pilbara and the construction of waste landforms and pits introduces new landforms into the landscape.
Generation of AMD (indirect impact)	Exposure of sulfide-bearing rocks to atmospheric oxygen through excavation and dewatering resulting in sulfide oxidation and the generation of AMD. This can this impact soils and surface water and groundwater, which can then impact ecosystems.
Increased erosion (indirect impact)	Surface erosion of final landforms has potential destabilise final landforms resulting in an unacceptable closure outcome or may to increase turbidity in surface water.

8.1.6.3 MITIGATION

Key mitigation tools for landforms and terrestrial environmental quality are presented in Section 8.5.1.4, Rehabilitation and Decommissioning Management Toolkit.

8.1.6.4 SIGNIFICANCE OF IMPACTS

The primary basis for the EPA's determination of the likely significance and acceptability of a proposal is whether it is likely to meet the EPA's objectives for each environmental factor. The EPA uses a significance framework to determine the likely significance of a proposal and to make decisions throughout the environmental impact assessment process, as outlined in EPA Environmental Assessment Guideline No. 9 (EPA 2015b). If the EPA considers that a proposal can meet all of its objectives, then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives, then its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives, then its effect on the environment is likely to be unacceptable.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework to determine whether the proposal can meet the EPA objectives for each environmental factor. For the purposes of evaluating significance to terrestrial environmental quality and landforms, the significance test has been guided by EPA Bulletin 23: Landforms (EPA 2015d). This EPA bulletin considers the variety, integrity, ecological importance, scientific importance and rarity of landforms to be important. To assess these aspects, the impact assessment uses landscape units, landform types and land systems as a basis. The results are discussed below. Significance of impact to terrestrial environmental quality is also discussed below.

Impacts to Landforms

An assessment of direct impacts to landscape types and their associated landforms was undertaken by GHD and 360 Environmental (Appendix 8) in which the areas directly impacted by third-party operations and BHP Billiton Iron Ore's 30% Conceptual Development Scenario and Full Conceptual Development Scenario were quantified and assessed relative to the total extent of a given landscape type (mostly restricted to the Pilbara bioregion and neighbouring bioregions). The results are presented in Table 34.

The maximum impact from the Strategic Proposal occurs to the Hamersley Plateaux landscape unit where an additional 2.111% of the unit will be impacted. Over 96% of the Hamersley Plateau landscape unit will remain unaffected from cumulative developments.

Table 34: Predicted impact to pre-European extents of broad landscape units

Landscape Unit	Current Extent (% pre-European) undisturbed, including existing impacts from BHP Billiton Iron Ore and Third Parties	% pre-European Extent Impacted (additional to existing impacts)		Predicted combined Additional impact (%)	Predicted combined % pre-European extent undisturbed post-impact
		% BHP Billiton Iron Ore Impacts[1]	% Third-party Impacts		
Hamersley Plateaux	99.10	1.815	0.296	2.111	96.99
Fortescue Valley	99.57	1.132	1.872	3.004	96.57
Bulloo Plains and Hills	99.94	0.121	0.038	0.159	99.78
Chichester Ranges	99.84	0.274	0.201	0.475	99.37
Jigalong Plains	100.00	-	0.133	0.133	99.87
Warrawagine Hills	99.73	-	0.001	0.001	99.73

1. BHP Billiton Iron Ore impacts are based on the Full Conceptual Development Scenario, excluding existing impacts.

As iron ore deposits are typically associated with a specific set of landforms, it is expected that the proportion of impact to certain landscapes will be considerably different from the proportion of impact to others.

The impacts to landform types (expressed as a proportion of the landform's Pilbara-wide extent) are presented in Table 35. The landform types are mapped at a finer scale than the broad landscape units presented in Table 34. The maximum impact from the Strategic Proposal occurs to the Dissected Plains and Stony Plains landform types where an additional 0.625% of the units occurs within the Full Conceptual Development Scenario footprint. Over 98% of these landform types will remain unaffected from the cumulative direct disturbance.

Table 35: Cumulative impacts to dominant landforms for land systems affected by the Strategic Proposal

Dominant Landform[1]	Current Extent (% pre-European) undisturbed, including existing impacts from BHP Billiton Iron Ore and Third Parties	% pre-European Extent Impacted (additional to existing impacts)		Combined Additional Impact (%)	Predicted combined % pre-European extent undisturbed post-impact
		% BHP Billiton Iron Ore Impacts	% Third-party Impacts		
Hills and Ranges	99.71	0.519	0.112	0.631	99.08
Plateaux, Mesas and Breakaways	99.63	0.147	0.039	0.186	99.44
Dissected Plains	99.74	0.626	0.084	0.710	99.03
Stony Plains	99.84	0.625	0.146	0.771	99.07
Sandplains	99.69	0.025	0.055	0.080	99.61
Washplains	99.39	0.593	0.682	1.275	98.12
Alluvial Plains	99.33	0.106	0.550	0.656	98.67
River Plains	99.87	0.174	0.142	0.316	99.55
Calcreted Drainage Plains	99.93	0.307	0.026	0.333	99.60

1. Landscape units do not include Stony Gilgai Plains and Salt Lakes as these are not within the Strategic Proposal footprint.

Table 36 provides the direct disturbance impact to land systems from BHP Billiton Iron Ore and third-party iron ore mining in the Pilbara. Existing impacts have been considered in the column representing 'current extent', which presents the proportion of pre-European extent remaining after existing mining (BHP Billiton Iron Ore and third party) and general land clearing (DAFWA 2012) are taken into consideration.

Table 36: Direct impact to extent of land systems within the Project Definition Boundary

Land Systems	Current Extent (% pre-European) undisturbed, including existing impacts from BHP Billiton Iron Ore and Third Parties	% pre-European Extent Impacted (additional to existing impacts)		Predicted combined Additional impact (%)	Predicted combined % pre-European extent undisturbed post-impact
		% BHP Billiton Iron Ore Impacts	% Third-party Impacts		
Boolgeeda System	98.99	2.219	0.447	2.666	96.32
Brockman System	99.99	0.785	-	0.785	99.21
Cadgie System	100	0.117	-	0.117	99.88
Calcrete System	99.87	0.711	0.061	0.772	99.10
Christmas System	99.58	0.804	0.01	0.814	98.77
Divide System	99.81	0.137	0.294	0.431	99.38
Egerton System	100	0.180	-	0.18	99.82
Elimunna System	97.64	1.194	-	1.194	96.45
Fan System	99.55	0.249	3.146	3.395	96.16
Jamindie System	99.62	0.361	0.980	1.341	98.28
McKay System	99.24	0.428	0.127	0.555	98.69
Newman System	99.16	2.662	0.569	3.231	95.93
Nooingnin System	100	0.066	-	0.066	99.93
Oakover System	99.94	0.246	0.004	0.25	99.69
Pindering System	99.05	4.834	0.059	4.893	94.16
Platform System	98.87	1.954	0.302	2.256	96.61
River System	99.19	0.237	0.148	0.385	98.81
Robe System	96.31	0.529	0.174	0.703	95.61
Rocklea System	99.90	0.042	0.006	0.048	99.85
Spearhole System	99.75	0.721	0.539	1.26	98.49
Sylvania System	99.96	0.199	0.862	1.061	98.90
Table System	99.97	0.005	0.030	0.035	99.94
Turee System	99.40	0.046	3.322	3.368	96.03
Urandy System	99.78	0.444	3.037	3.481	96.30
Wannamunna System	99.80	9.847	0.565	10.412	89.39
Washplain System	99.85	0.580	0.097	0.677	99.17

Land Systems	Current Extent (% pre-European) undisturbed, including existing impacts from BHP Billiton Iron Ore and Third Parties	% pre-European Extent Impacted (additional to existing impacts)		Predicted combined Additional impact (%)	Predicted combined % pre-European extent undisturbed post-impact
		% BHP Billiton Iron Ore Impacts	% Third-party Impacts		
Zebra System	100	1.757	-	1.757	98.24

Source: Appendix 8

1. Land systems with no impacts have been omitted from the table.

2. These estimates of impact from the 30% Conceptual Development Scenario and Full Conceptual Development Scenario exclude previously disturbed areas (i.e. the proportion estimate for the 30% Conceptual Development Scenario excludes existing impacts, and the Full Conceptual Development Scenario excludes the 30% Conceptual Development Scenario and existing impacts).

The Wannamunna System was found to exceed 10% when cumulative impacts were taken into account. This land system consists primarily of the washplain landform, the third most common landform in the Project Definition Boundary, accounting for approximately 13.5%.

Although some direct impacts to some land systems are relatively high, the impacted systems do not comprise unique landforms and therefore do not represent a significant impact to landforms as a result of the Strategic Proposal.

Impacts to Terrestrial Environmental Quality

The two main characteristics of soils and geological formations that are relevant to iron ore mining and that influence terrestrial environmental quality are physical characteristics that can lead to erosion and geochemical characteristics that can lead to AMD. Both of these characteristics are discussed below.

Erosion Potential

The most comprehensive data available on erosion potential across a large portion of area within the Project Definition Boundary is provided by Payne (2004) (in van Vreeswyk et al. 2004).

The Land and Biodiversity Management toolkit and the Rehabilitation and Decommissioning toolkit provide management measures that ensure that the erosion potential of waste material is taken into account when designing, scheduling and constructing OSAs and other landforms. Given the processes in place to manage erosion potential, BHP Billiton Iron Ore considers the impacts to terrestrial environmental quality from erosion associated with the Strategic Proposal to be low.

Figure 40 shows areas with high erosion potential that occur in the major river valleys and associated plains. Payne (2004) noted that erosion in the Pilbara was predominantly caused by grazing and that, although some impacts from mining resulting in erosion were noted, these were highly localised.

The geological formations in which BHP Billiton Iron Ore mines are located are Brockman Iron and Marra Mamba Iron formations and channel iron deposits. The erosion potential for these deposits are summarised in Table 37.

Table 37: Erosion potential of waste types that occur in BHP Billiton Iron Ore operations

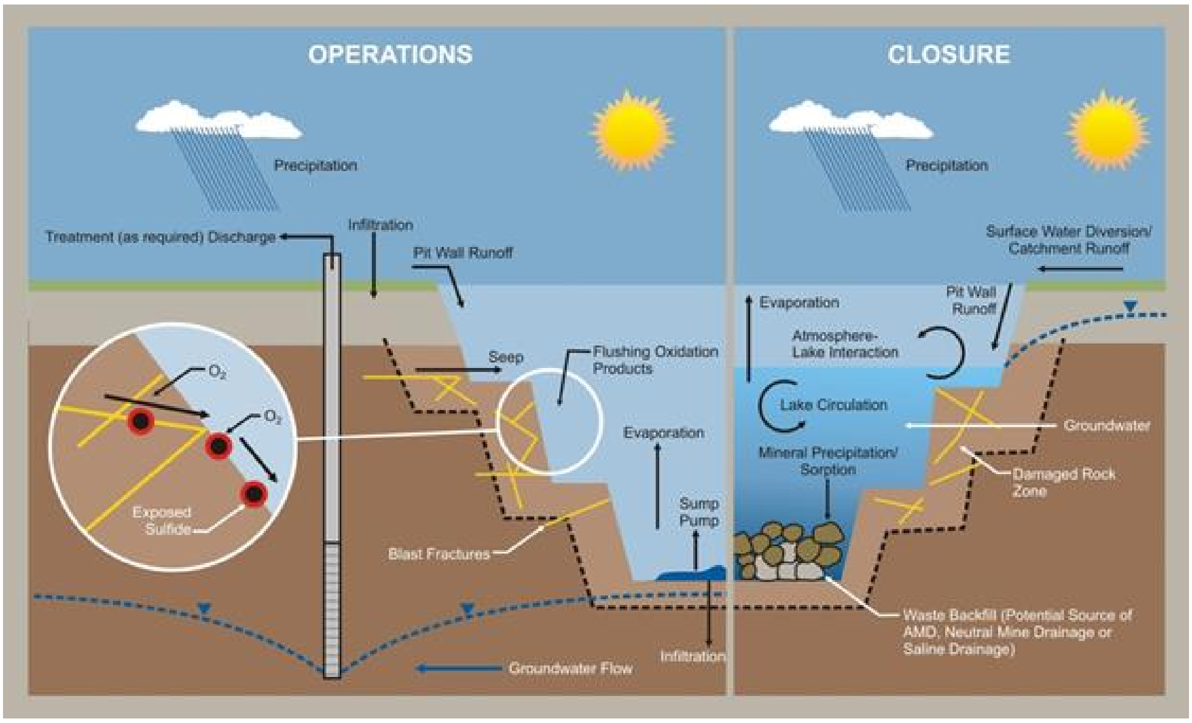
Geological Formation	Physical Characteristics
Marra Mamba	The majority of the wastes associated with the Marra Mamba deposits are considered highly erodible (Landloch 2013), requiring consideration in the overburden storage area design and construction techniques to provide a stable landform.

GEOLOGICAL FORMATION	PHYSICAL CHARACTERISTICS
Brockman	Brockman deposits contain the stratigraphic units of Dales Gorge and Joffre materials predominantly along with other minor stratum. The material characterisation work has shown that Brockman material is significantly less susceptible to surface erosion than the Marra Mamba waste materials. The Brockman material provides an opportunity to stabilise Marra Mamba waste materials.
Channel iron deposits	Channel iron deposits occur at the surface of a mine void; therefore, there is generally no waste type associated with this formation.

Acid Metalliferous Drainage

As discussed in Section 8.1.6.2, AMD can occur when certain geological types are brought to the surface during mining. A conceptual schematic of AMD sources and pathways during open-cut mining below the water table and from the same mine void after closure is provided in Figure 39.

The Land and Biodiversity Management toolkit and Rehabilitation and Decommissioning toolkit provide management measures that ensure that AMD is taken into account when designing, scheduling and constructing operations. Given the processes in place to manage AMD potential, BHP Billiton Iron Ore considers the impacts to terrestrial environmental quality from AMD associated with the Strategic Proposal to be low.



Source: INAP (2010).

Figure 39: AMD sources and pathways during open-cut operations and after closure

BHP Billiton Iron Ore conducted an assessment of AMD potential for all of its current mining operations and future deposits using a risk-based approach (Appendix 7). Source-pathway-receptor information is available for some of BHP Billiton Iron Ore's deposits; however, many deposits do not have sufficient planning details for pathways and receptors to be characterised at this time. Characterisation will continue to be enhanced at the project planning and design phases., with mitigation measures specified in the Derived Proposal, to ensure that any impacts to the environment from AMD continue to be acceptable.

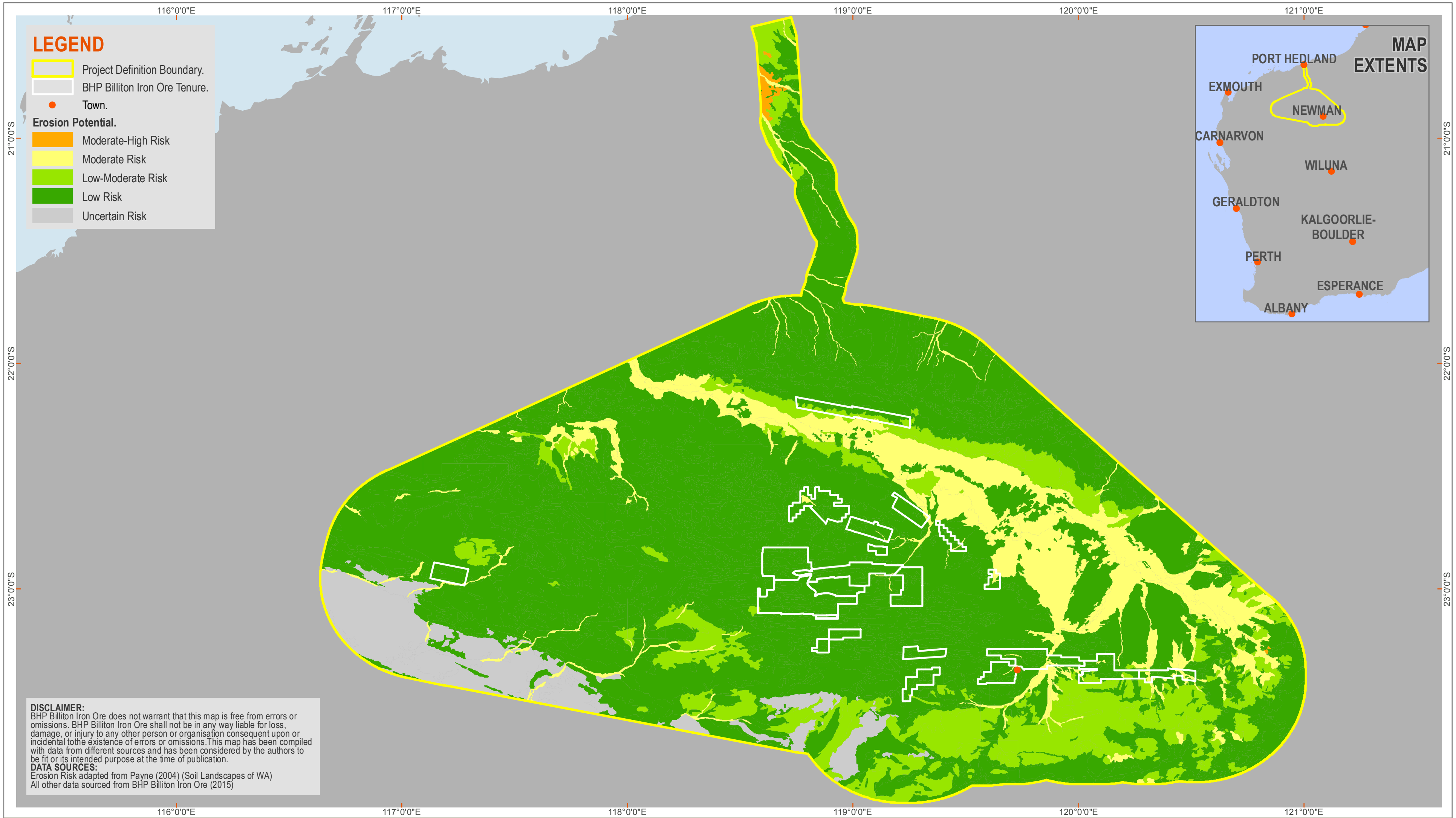


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Figure 40 Erosion potential within the Project Definition Boundary

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Figure 41 shows the AMD potential associated with the Full Conceptual Development Scenario. The majority of the proposed orebodies associated with this scenario were assessed to have low AMD source risk potential.

There is high risk of AMD at Whaleback. As the mine void is located in a poorly connected groundwater system, there is a low potential for AMD to be transported away from the final pit void. Mindy is also considered to be high risk based on the indicative size of the ore resource; however, no mine plans have been developed for the individual orebodies as yet, so this is likely a conservative assessment. Mine plans will assist in the verification of AMD potential via the identification of leachable content and release potential.

The AMD risk assessment assesses the likelihood of encountering PAF mine overburden or exposed PAF surfaces within the excavated mine voids. Such material is likely to present as high-risk material in AMD assessment in terms of leaching of constituents of interest, particularly acidity, metals and salinity. PAF material is therefore of particular interest because, when disturbed, it presents the source of risk for potential ecohydrological change. The characteristics of disturbed geological material that were considered to be the basis of AMD risk were leachable content of AMD in the source term and potential for leaching to occur based on the material's properties.

The characteristics of the material may be divided into the key attributes of the material and the disturbance created when the material is mined (Table 38).

Table 38: Factors controlling consequence and likelihood of AMD risk

CONSEQUENCE (LEACHABLE CONTENT)	LIKELIHOOD (RELEASE POTENTIAL)
Magnitude of disturbance (tonnes)	Residual reactivity (degree of in-situ weathering, qualitative assessment)
Leachable solid concentration of COI (mg/kg)	Change in environment (undisturbed to disturbed condition, qualitative assessment) Kinetics of release (mg/y, or qualitative assessment)

Input data used in the risk assessment were:

- Deposit type (Brockman Iron and Marra Mamba Iron formations and channel iron deposits);
- Tonnes of material mined;
- Ore and overburden classifications;
- Preliminary PAF classifications, based upon total sulfur content of 0.2% sulfur from assay; and
- Information on whether material was mined from above or below the watertable.

An assessment of the proportion of potential acid forming material (PAF material) classified ore and overburden material was made for each host formation (Brockman Iron and Marra Mamba Iron formations and channel iron deposits). The assessment indicated that a relationship exists between host rock type and the proportion of PAF material associated with it. The presence of PAF material has been used as an indicator for leachability of the overburden generated from it in terms of the release of constituents of concern (e.g. metals, sulfate), where leachability information is unavailable. The validity of the indicator used is based on two main assumptions:

- a particular deposit type generates different magnitudes of AMD risk, based on the amount of PAF material likely to be disturbed; and
- PAF material is likely to represent high AMD risk material, given that leachability of constituents of concern (e.g. metals, sulfate) are enhanced under acidic conditions.

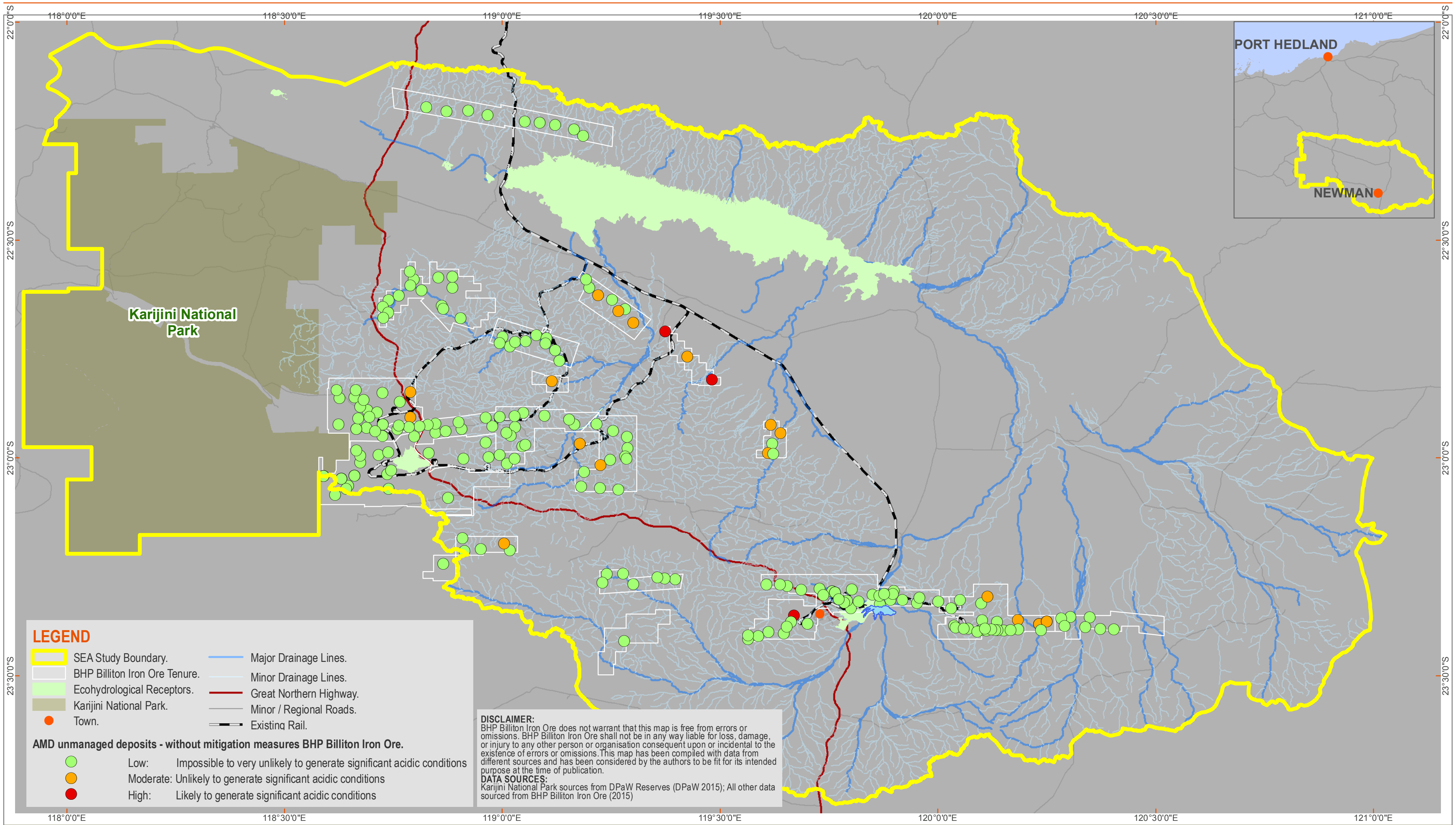

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Figure 41 AMD potential at the Full Conceptual Development Scenario

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The review of data from the mine models provided the basis for a significance scale, expressed as a proportion of PAF material. From the data review (refer to Appendix B of Appendix 7), the following conclusions were drawn for the likelihood of encountering PAF overburden (summarised in Table 39):

- Brockman Iron Formation: Range of PAF in AMD risk assessments was 0.03% to 6% (most mines will have possible AMD potential);
- Marra Mamba Iron Formation: Range of PAF in AMD risk assessments was 0.3% to 6% (most mines will have unlikely AMD potential); and
- Channel iron deposits: Range of PAF in AMD risk assessments was 0% to 0.01% (most mines will have rare AMD potential)

Given that AMD and erosion risk from BHP Billiton Iron Ore operations is well understood and management measures are in place to manage these risks (refer to the Land and Biodiversity Management toolkit, Figure 17 and the Rehabilitation and Decommissioning toolkit, Figure 70), BHP Billiton Iron Ore considers that impacts of the Proposal on terrestrial environmental quality are likely to be low.

Table 39: PAF characteristics of host rock geology

LIKELIHOOD OF ACID GENERATION	DESCRIPTOR	HOST ROCK GEOLOGY
High	May happen	Brockman
Medium	May happen sometime	Marra Mamba
Low	May happen in extreme circumstances	Channel Iron Deposit

8.1.7 SUMMARY OF ASSESSMENT OUTCOMES

This section provides a summary of the assessment outcomes for Land environmental factors using the EPA's Environmental Guideline 9 (EPA 2015b) and presents BHP Billiton Iron Ore's view on whether the Strategic Proposal can be implemented consistent with the EPA's objectives.

Regional Biodiversity Values

BHP Billiton Iron ore considers that potential impacts within the Juna Down pastoral lease exclusion area will be managed to an acceptable level given the stakeholder engagement activities that BHP Billiton Iron Ore has committed to for any future Derived Proposal referral.

BHP Billiton Iron Ore recognises that both direct and indirect impacts to TECs will require effective management to ensure that objectives for Tier 1 assets are met. For example, management of the groundwater regime at Ethel Gorge will maintain stygofauna habitat and is one of the principle considerations in BHP Billiton Iron Ores regional water management planning for the Eastern Pilbara. BHP Billiton Iron Ore considers that, given its operational experience in managing impacts to surface water and groundwater in the Pilbara, impacts to these environmental assets managed to an acceptable level.

Flora and Vegetation

BHP Billiton Iron Ore considers that impacts to Flora and Vegetation will be acceptable, given that the extent of flora and vegetation representation in the region will not be significantly impacted by BHP Billiton Iron Ore activities.

The cumulative impact to the above Beard vegetation associations will result in a reduction to 93.5% and 81.1% of the pre-European extent respectively. Both of these vegetation associations occur outside of the Pilbara bioregion and are common and widespread in the Pilbara region.

None of the consolidated vegetation associations mapped on BHP Billiton Iron Ore tenure are located within formally recognised PECs or TECs, so are considered to be Tier 3 Assets for the purposes of management. In some cases, validation at the Derived Proposal stage may indicate that vegetation associations are representative of TECs, which would then be considered as Tier 1 assets. Given BHP Billiton Iron Ore's commitment manage impacts to these areas in line with the key regional asset management, BHP Billiton Iron Ore considers that impacts to conservation-significant vegetation associations will be managed to an acceptable level.

Synostemon hamersleyensis is considered to have potential to be significantly impacted from the Strategic Proposal. This species has only recently been described (2015), and knowledge on the species occurrence and ecology is still evolving. Given that *Synostemon hamersleyensis* may be impacted by approximately 50% under the Full Conceptual Development Scenario, BHP Billiton Iron Ore recognises that this species will require considered management as a Tier 2 species to meet the environmental objectives for flora and vegetation. BHP Billiton Iron Ore will validate that the objectives for flora and vegetation can be met as any future Derived Proposal referral at a local and regional scale using updated baseline data and considers detailed mine planning and design. Given this validation process, BHP Billiton Iron Ore considers that impacts to this species will be managed to an acceptable level.

Terrestrial Fauna

BHP Billiton Iron Ore recognises that without effective mitigation, there are potential significant impacts to some terrestrial fauna habitat types and known species locations.

BHP Billiton Iron Ore considers that impacts to fauna habitat can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Land and Biodiversity Management Toolkit. Validation of habitat extent and presence of conservation significant species as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for fauna, and also for areas of habitat that are key assets or support conservation –significant species.

Subterranean Fauna

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact subterranean habitat of high prospectivity through mining and groundwater drawdown. BHP Billiton Iron Ore considers that impacts to fauna habitat can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Land and Biodiversity Management Toolkit. Validation of habitat extent and requirements of subterranean fauna as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for subterranean fauna once detailed mine design and planning is determined.

Landforms and Terrestrial Environmental Quality

BHP Billiton Iron Ore considers potential impacts to landform extent to be acceptable, given that the extent of landscape units, landform types and land systems will remain high relative to their pre-European extents.

BHP Billiton Iron Ore considers that impacts to terrestrial environmental quality can be managed to an acceptable level through normal business management practices or though targeted management measures identified in Rehabilitation and Decommissioning toolkit. Validation as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for landforms and terrestrial environmental quality once detailed mine design and planning is determined.

8.2 Water

8.2.1 INTRODUCTION

8.2.1.1 ENVIRONMENTAL FACTOR OBJECTIVES

Table 40 outlines the environmental objectives from both the EPA and BHP Billiton Iron Ore for Water. As outlined in Section 4.2.1, BHP Billiton Iron Ore will contribute to the EPA Environmental Factor Objectives through its objective.

Table 40: EPA and BHP Billiton Iron Ore Environmental Factor Objectives for Water

FACTOR	EPA OBJECTIVE (EPA 2015A)	BHP BILLITON IRON ORE OBJECTIVE[1]
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected	BHP Billiton Iron Ore shall mitigate risks to hydrological processes from its activities to an acceptable level.
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected	BHP Billiton Iron Ore shall mitigate risks to inland waters environmental quality from its activities to an acceptable level.

1. 'Acceptable level' is defined as per the EPA's significance framework in Environmental Assessment Guideline 9 (EPA 2015b); thus BHP Billiton Iron Ore considers an 'acceptable level' of impact to be a level of residual impact that meets the EPA's objectives for that environmental factor.

8.2.1.2 KEY LEGISLATION AND GUIDANCE

As discussed in Section 7.1, BHP Billiton Iron Ore has addressed applicable legislation, policy and guidance for each factor. These are detailed in Appendix 1, Table 1.2.

8.2.1.3 WATER MANAGEMENT TOOLKIT

BHP Billiton Iron Ore has a suite of mitigation measures (a 'mitigation toolkit') that can be selected from to achieve the outcome-based objectives for environmental factors relating to Water. The management measures presented are not exhaustive. Additional measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied in line with BHP Billiton Iron Ore's adaptive management approach. BHP Billiton Iron Ore's Water Management toolkit is presented in Figure 42.

Management measures from the Water Management toolkit are provided as examples for each of the environmental factors relating to Water throughout Section 8.2.

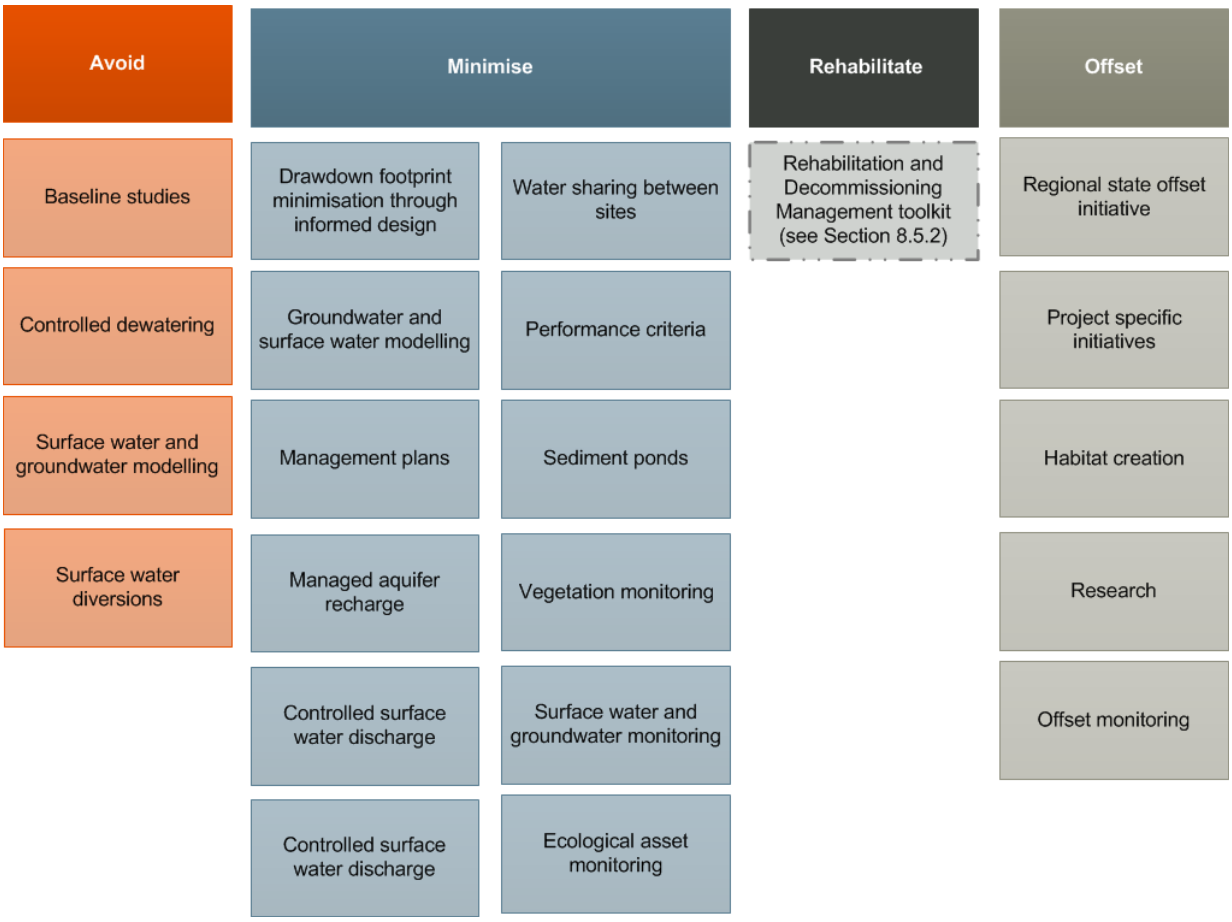

Figure 42: BHP Billiton Iron Ore's Water Management toolkit

8.2.2 HYDROLOGICAL PROCESSES AND INLAND WATERS ENVIRONMENTAL QUALITY ASSESSMENT

8.2.2.1 EXISTING ENVIRONMENT

The ecohydrological change assessment (ECA) (Appendix 7) provides a description of the regional hydrology of the Pilbara, with more specific information provided on key aspects that are potentially subject to hydrological influence from the Strategic Proposal within the Ecohydrology Study Boundary (see Figure 43). A summary of the existing environment described in the ECA is provided in this section.

Surface Water

The Strategic Proposal is almost entirely situated within the Upper Fortescue River Basin, which drains west towards the Indian Ocean and has a total catchment area of about 50,000 km^2. The Goodiadarrie Hills, west of the Fortescue Marsh, effectively separate the Fortescue River into the Lower Fortescue River and Upper Fortescue River. The Fortescue Marsh is a closed system that forms the surface flow terminus of the Upper Fortescue River.

Most regional drainage is towards the Fortescue Marsh. There is a small portion of drainage (less than 2%) in the southwest associated with Turee Creek East Branch, which is an upper tributary of the Ashburton River. Goodiadarrie Swamp is a small, internally draining subcatchment of the Lower Fortescue that is immediately west of and hydraulically separated from the Fortescue Marsh.

The main catchment areas within the Ecohydrology Study Boundary are shown in Figure 43. The Upper Fortescue River, Weeli Wolli Creek and Marillana Creek are major surface water drainages. Marillana

Creek drains into Weeli Wolli Creek and eventually towards the southwestern portion of the Fortescue Marsh whereas the Upper Fortescue River drains directly into eastern parts of the Fortescue Marsh. The combined catchment area for these drainages is 21,100 km^2, which is about 65% of the area within the Ecohydrological Study Boundary (the study area).

Mindy Mindy and Coondiner Creeks are smaller drainages emanating in the Hamersley Range to the east of Weeli Wolli Creek that discharge into the Fortescue Marsh. The Chichester Range includes numerous smaller drainages that discharge into the northern margins of the Fortescue Marsh.

There are two internally draining catchments associated with Coondewanna and Wannamunna flats. Surface water in the Coondewanna Flats catchment is captured in a closed drainage basin. that includes the ephemeral (seasonal) Lake Robinson. This area is considered to be an important zone of groundwater recharge. In the Upper Marillana Creek catchment, the Munjina Claypan is an important feature that attenuates flows in Marillana Creek Appendix 7 (see Section 3.1.1.3, Ecohydrological Conceptualisation of the Central Pilbara Region, in Appendix 6).

Surface runoff is generated when the rate of rainfall exceeds the water-holding or infiltration capacity of a water body (e.g., creek or river). Runoff generation is strongly influenced by geology, vegetative cover and slope, soil moisture derived from previous rainfall, and runoff and infiltration events. In the majority of landscapes, runoff is concentrated into drainage networks connecting with regional creek systems.

Drainage lines are well defined in the upper slopes where creeks are incised into the landscape. These lower-order tributaries converge into a small number of well-defined, higher-order drainages and associated floodplains. Riparian woodlands commonly fringe the main drainages and utilise water that replenishes the vadose zone (zone between the land surface and the deepest water table) following streamflow.

Drainages in flat-lying areas tend to be braided and indistinct. In some landscapes, certain combinations of topography, hydrological conditions and soil types give rise to sheet flow, which can be associated with banded-vegetation communities. During significant rainfall events, floodwater can overflow creek channels and extend across wider floodplains. This is an important mechanism in these areas for replenishing soil moisture and recharging groundwater resources.

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Figure 43 Surface water catchment areas

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All river and creek drainages are ephemeral. Streamflow typically occurs during the summer months of December to March and is associated with large and intense rainfall events from tropical cyclones and thunderstorms.

In rare situations, groundwater can discharge to the surface and contribute to surface water flow, such as at Weeli Wolli Spring. The occurrences of springs and groundwater-fed pools across the study area are spatially restricted and often geologically controlled. Where present, these areas often support distinct biota and ecosystems.

Groundwater

Groundwater resources in the Pilbara are replenished through the processes of direct infiltration from rainfall and surface water flows. This groundwater is most readily accessed via alluvial channels and surface water drainage lines (DoW 2010). Generally, groundwater flow is a reflection of topography, flowing in a northerly direction towards the coast (FMG 2012). There are a range of aquifer types in the Pilbara, with the majority in the central and eastern Pilbara comprising complex fractured-rock aquifers with irregular structures and different recharge mechanisms. In addition, these aquifers support a range of groundwater-dependent ecosystems (DoW 2013a).

The regional groundwater system comprises Tertiary detritals and underlying Wittenoom Formation (dominated by Paraburdoo Member dolomite) that is bound within low-permeability geological types. There are localised areas of higher permeability associated with orebody aquifers, geological structures and preferential weathering profiles that are in variable hydraulic connection with the regional groundwater system. Channel iron deposits are localised orebody aquifers having variable connectivity with surface water systems, such as within Marillana Creek.

The dolomite aquifer of the Wittenoom Formation occurs at depth beneath most of the Fortescue River Valley and the major drainage features, such as Weeli Wolli Creek. The dolomite has a low permeability where it is fresh and relatively unfractured; however, over time underground drainage systems have formed through karstification, which has enhanced its permeability and aquifer potential. As the dolomite has been weathered to form valleys and in-filled with Tertiary sediments, there is strong hydraulic connectivity between the dolomite and detrital aquifers that collectively comprise the ‘regional groundwater system’ (Figure 44).

As the landscape rises into the ranges away from the valleys, the hydrogeology features a complex assortment of fractured-rock aquifers. Mineralised zones in the Brockman Iron and Marra Mamba Iron formations can have enhanced permeability, and aquifer potential is limited below and along strike by low-permeability unmineralised banded iron formation. The extent of orebody aquifers and hydraulic connectivity with the regional groundwater system may be enhanced by site-specific faulting or preferential weathering.

Structural features have an important influence on groundwater flow and connectivity. Whaleback, Fortescue River and Wheelarra faults in the eastern Pilbara region are transverse faults (which are oblique or perpendicular to the dominant geology) that form low-permeability barriers that restrict the movement of groundwater. Dolerite dykes can also impede groundwater flow. In contrast, local thrust faults have improved permeability through the fragmentation of the dolomite aquifer and have resulted in direct hydraulic connection between orebodies and the regional groundwater system.

Channel iron deposits form both orebodies and important aquifers that can act as regional groundwater drains, most notably along Marillana Creek. In places, channel iron deposit aquifers are in hydraulic connection with the alluvium in present-day creeks. Alluvial and colluvial sediments comprising the Tertiary detritals range from localised unconfined aquifers of limited lateral extent in upland areas through to extensive groundwater systems, for example, where associated with the main drainages of Weeli Wolli Creek, upgradient of Ethel Gorge and within the Fortescue River Valley.

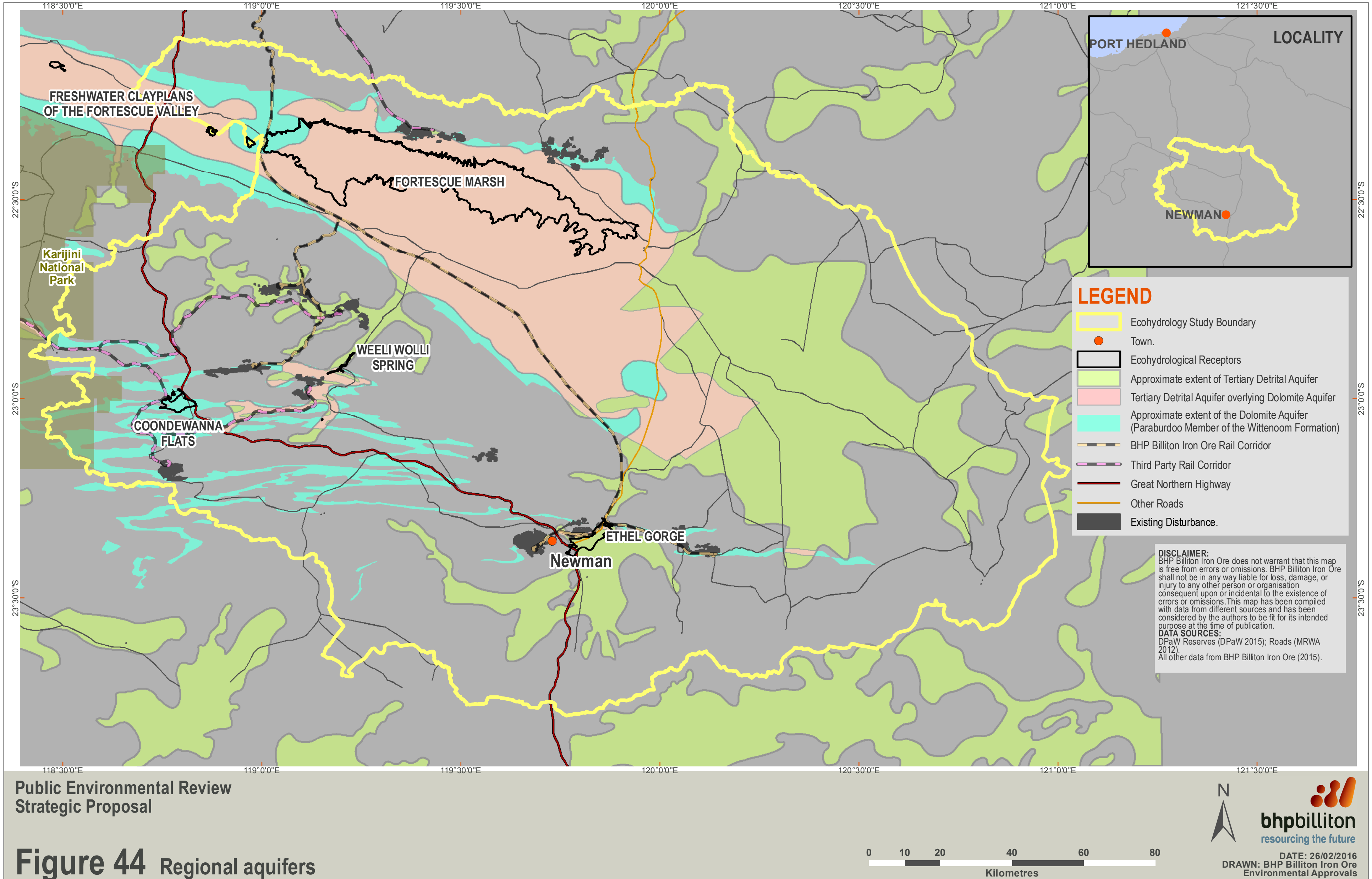

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Figure 44 Regional aquifers

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Saturated thickness progressively increases from the margins of the Chichester and Hamersley ranges into the main valleys and is greatest in the lower parts of the landscape. In places, the Tertiary detritals have been calcretised and karstified to form zones of higher permeability, which often constitute important aquifers and habitat for stygofauna.

Groundwater recharge is mainly associated with surface water flow along creeks and with areas of water impoundment. Diffuse recharge is less significant for the regional water balance. Large soil moisture deficits generally prevent recharge where groundwater levels are greater than 30 m below ground level (bgl). In contrast, where surface water accumulates and depth to water is shallow (less than about 15 m bgl), recharge occurs on an annual basis associated with streamflow. Elsewhere, recharge through infiltration is infrequent and inconsistent.

Groundwater discharge is primarily associated with spring baseflow, throughflow within aquifers, and evapotranspiration losses. Within the study area, the discharge of groundwater into surface water features is rare and depends on site-specific geology. A noticeable occurrence is at Weeli Wolli Spring, where regional groundwater flow is concentrated into a shallow aquifer that is further constrained by a gorge in Wildflower Range.

Across the study area, groundwater is fresh to marginally brackish being less than 1,500 mg/L total dissolved solids with localised areas of slightly elevated groundwater salinity associated with evapotranspiration by phreatophytic vegetation (e.g. at Ethel Gorge and Weeli Wolli Spring). The main exception is the Fortescue River Valley where a mound of saline to hypersaline groundwater has formed beneath the Fortescue Marsh. This saline groundwater system is the product of internal drainage and high evaporation rates over a long period (Skrzypek et al. 2013). Towards the valley flanks, there is a freshwater–saltwater interface within the Tertiary detrital aquifer.

Ecohydrology

The climate and surface water regime greatly influence the nature and distribution of ecosystems across the landscape. Terrestrial ecosystems with a dependency on groundwater are uncommon and typically restricted to riparian habitats where groundwater is relatively shallow. Aquifers support subterranean ecosystems, which frequently include species with restricted distributions (Appendix 7).

Ecohydrology is the study of the interactions and relationships between hydrological processes and ecosystem patterns and dynamics. A landscape-scale ecohydrological conceptualisation of the study area was developed to:

- enable the identification of environmental assets with a high level of ecohydrological connectivity (considered to be ecohydrological receptors); and
- provide a basis for assessing the potential of current and proposed mining operations to affect ecohydrological receptors via the alteration of hydrological regimes.

Under the conceptualisation, nine landscape-scale ecohydrological units (EHUs) were defined with broadly consistent and distinctive ecohydrological attributes. A description of the EHUs and their relationship to surface water and the groundwater regime is provided in Table 41 and Figure 45.

The ecohydrological conceptualisation provides a basis for identifying and characterising the susceptibility of landscape elements to regional-scale change in surface and groundwater regimes.

The EHUs are principally derived from surface features and are therefore not necessarily representative of the subsurface groundwater environment. Despite this limitation, it is possible to discern broad relationships between EHUs and groundwater systems based on depth to water table information. Depth to water table is widely referenced as a reliable indicator of potential connectivity between groundwater-dependent ecosystems and groundwater resources, with vegetation dependency generally identified where groundwater is less than 10 m bgl (Sommer & Froend 2014; Braimbridge et al. 2010; Loomes 2010; Rutherford et al. 2005).

Table 41: General description of ecohydrological units

DESCRIPTION (EHU)	SURFACE WATER PROCESSES	CONNECTIVITY WITH GROUNDWATER REGIME	MAJOR VEGETATION TYPES
1. Upland source areas – hills, mountains and plateaux. Land surface is steep and rocky. Shallow or skeletal soils, with frequent bedrock exposures.	Generally, short-distance overland flow into dendritic drainage networks (first- to third-order streams). Low sensitivity to change.	Groundwater systems are deep and not accessible to vegetation. Low sensitivity to change.	Hummock grasslands. Vegetation water demand met by direct rainfall and localised surface runoff.
2. Upland source areas – dissected slopes and plains, downgradient from EHU 1. Land surface is sloping, with shallow to moderately deep colluvial soils.	Overland flow short distance into channel drainage systems (mainly first- to fourth-order streams). Low sensitivity to change.	Groundwater systems are deep and not accessible to vegetation. Low sensitivity to change.	Hummock grasslands. Vegetation water demand met by direct rainfall and localised surface runoff.
3. Upland transitional areas – drainages within EHUs 1 and 2 that accumulate surface water flow from upgradient. Alluvial soils of variable depth, with greater storage capacity relative to soils in EHUs 1 and 2.	Accumulation and infiltration of streamflow with some overland flows and channel breakouts. Excess volumes transferred to adjacent channels (EHU 4). Moderate sensitivity to change.	Groundwater systems are deep and not accessible to vegetation. Preferential recharge may occur as dictated by local-scale geology. Low sensitivity to change.	Smaller creek beds support hummock grasslands; larger creek beds support *Eucalyptus* and *Acacia* shrublands and woodlands. Vegetation water demand met by direct rainfall and stored soil water replenished by infrequent flood events.
4. Upland channel zones – channel systems of higher-order streams within EHUs 1 and 2. Channels are high-energy flow environments, subject to bed load movement and reworking.	Channel beds and banks accept and store water during flow events. Moderate flows are transmitted downgradient. Channels may support intermittent pools replenished by flood flows. Moderate sensitivity to change.	Regional groundwater systems are deep and not accessible to vegetation. Transient or less persistent shallow groundwater systems may develop beneath channels in places. Low sensitivity to change.	Channels are often lined with narrow woodlands of *E*. *victrix*, *A*. *citrinoviridis* or other *Eucalyptus* and *Acacia* species. These are sustained by soil water replenishment from flow events.
5. Lowland sandplains – flat to gently undulating plains with deep sandy soils of aeolian origin and linear dunes up to about 15 m in height.	Poorly organised drainage. High rainfall infiltration in sandy areas. Runoff is minimal with localised accumulation in swales and depressions. Sandplains may receive and infiltrate inflows from upgradient	Groundwater systems are generally moderately deep (greater than 10 m) to deep (greater than 30 m) and rarely accessed by vegetation. Possible localised perching of groundwater.	Hummock grasslands with *Acacia* sp. and other shrubs. Distinctive grassland communities relative to other EHUs.

DESCRIPTION (EHU)	SURFACE WATER PROCESSES	CONNECTIVITY WITH GROUNDWATER REGIME	MAJOR VEGETATION TYPES
	areas. Low sensitivity to change.	Moderate sensitivity to change.	
6. Lowland alluvial plains – broad depositional alluvial plains of low relief. Subsurface calcareous hardpans may be encountered.	Complex surface water drainage network with low-energy channels; areas of sheet flow associated with banded-vegetation types. Some areas subjected to infrequent flooding. Infiltration may be significant at local scales in association with drainage foci. Low sensitivity to change.	Groundwater systems are generally moderately deep (greater than 10 m) to deep (greater than 30 m) and rarely accessed by vegetation. Moderate sensitivity to change.	*Acacia* shrublands; less commonly hummock grasslands, tussock grasslands or low shrublands of bluebush and saltbush.
7. Lowland calcrete plains – areas of low relief bordering major drainage tracts and termini. Shallow soils associated with calcrete mounds that occasionally outcrop.	Complex surface water drainage networks. Calcrete areas have increased potential for infiltration. Land surfaces are generally dissected by low-energy drainages, and there are often numerous drainage termini. Low sensitivity to change.	Depth to groundwater can vary from shallow (less than 5 m) to deep (greater than 20 m). Localised pathways may facilitate rapid recharge. Groundwater systems are rarely accessed by vegetation but may support stygofauna assemblages. High sensitivity to change.	Hummock grasslands and *Acacia* scrublands with occasional *Eucalypts*. Distinctive vegetation communities relative to other EHUs.
8. Lowland major channel systems and associated floodplains – channels are high-energy flow environments subjected to bed load movement and reworking and supporting large flow volumes in flood events. Their distribution may be modified during cyclonic floods.	Channel beds and banks accept and store water during flow events. Large flows are transmitted downgradient. Soil water in the floodplains is replenished during flooding breakouts. The channels support transient, persistent and permanent riverine pools. High sensitivity to change.	Depth to groundwater can vary from shallow (less than 5 m) to deep (greater than 20 m). Shallow groundwater is often present beneath channels that may be connected with pools on occasions. The water table is opportunistically accessed by vegetation. Evaporative discharge of shallow groundwater may occur. High sensitivity to change.	Inflows from upgradient sources sustain *Eucalyptus* and *Acacia* forest and woodland vegetation communities or tussock grasslands. Supports most recognised groundwater-dependent vegetation communities in the Pilbara, including the key indicator species of *Eucalyptus camaldulensis, E*. *victrix* and *Melaleuca argentea*.
9. Lowland receiving areas – drainage	Drainage termini receive inflows from	Depth to groundwater can vary from	Fringed or occupied by distinctive vegetation

DESCRIPTION (EHU)	SURFACE WATER PROCESSES	CONNECTIVITY WITH GROUNDWATER REGIME	MAJOR VEGETATION TYPES
termini in the form of ephemeral lakes, claypans and flats. Deep silty and clay-textured soils with calcrete and silcrete hardpans. Variable surface water salinity that may result in evaporation.	upgradient drainages. Transient to persistent ponding may occur as dictated by flooding regimes, with spillover possible in large flooding events. Sediment accumulation and evaporative concentration of salts. High sensitivity to change.	shallow (less than 5 m) to deep (greater than 20 m). Groundwater may be fresh, brackish or saline. The water table may be opportunistically accessed by vegetation in some situations. Evaporative discharge of shallow groundwater may occur. High sensitivity to change.	communities, such as samphire. Regularly inundated areas may be largely devoid of vegetation. Vegetation adapted to waterlogging, flooding and salinity stressors. Potential to support groundwater-dependent ecosystems, depending on the level of surface and groundwater connectivity; however, this is unlikely to be common.

Source: Appendix 7

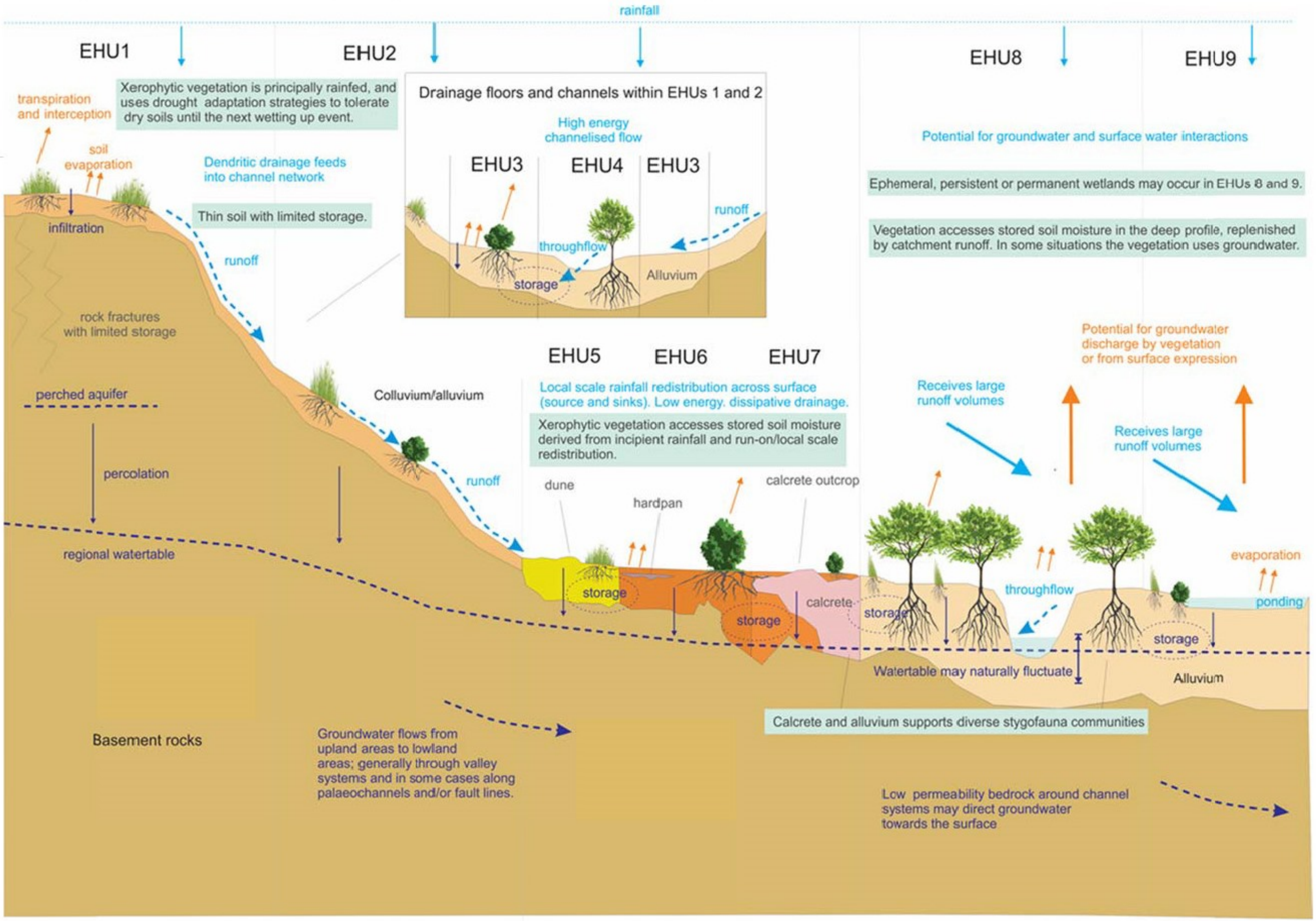


Figure 45: Landscape arrangement of ecohydrological units

Sensitivity to changes in groundwater regimes was rated as low in areas interpreted to have a deep water table (typically greater than 30 m bgl). In these areas, groundwater is disconnected from surface ecosystems, which instead rely on surface water inputs to satisfy their ecological water requirements. Sensitivity is rated as moderate in areas interpreted to have a groundwater depth between 10 and 30 m bgl. In these areas, there is limited potential for groundwater use by vegetation; however, there is an increased likelihood of the occurrence of stygofauna populations in groundwater systems. Sensitivity is rated as high in areas interpreted to have shallow groundwater of less than 10 m bgl. These areas have an increased likelihood of surface water and groundwater interaction and have the greatest potential to support groundwater-dependent vegetation, wetlands and stygofauna communities.

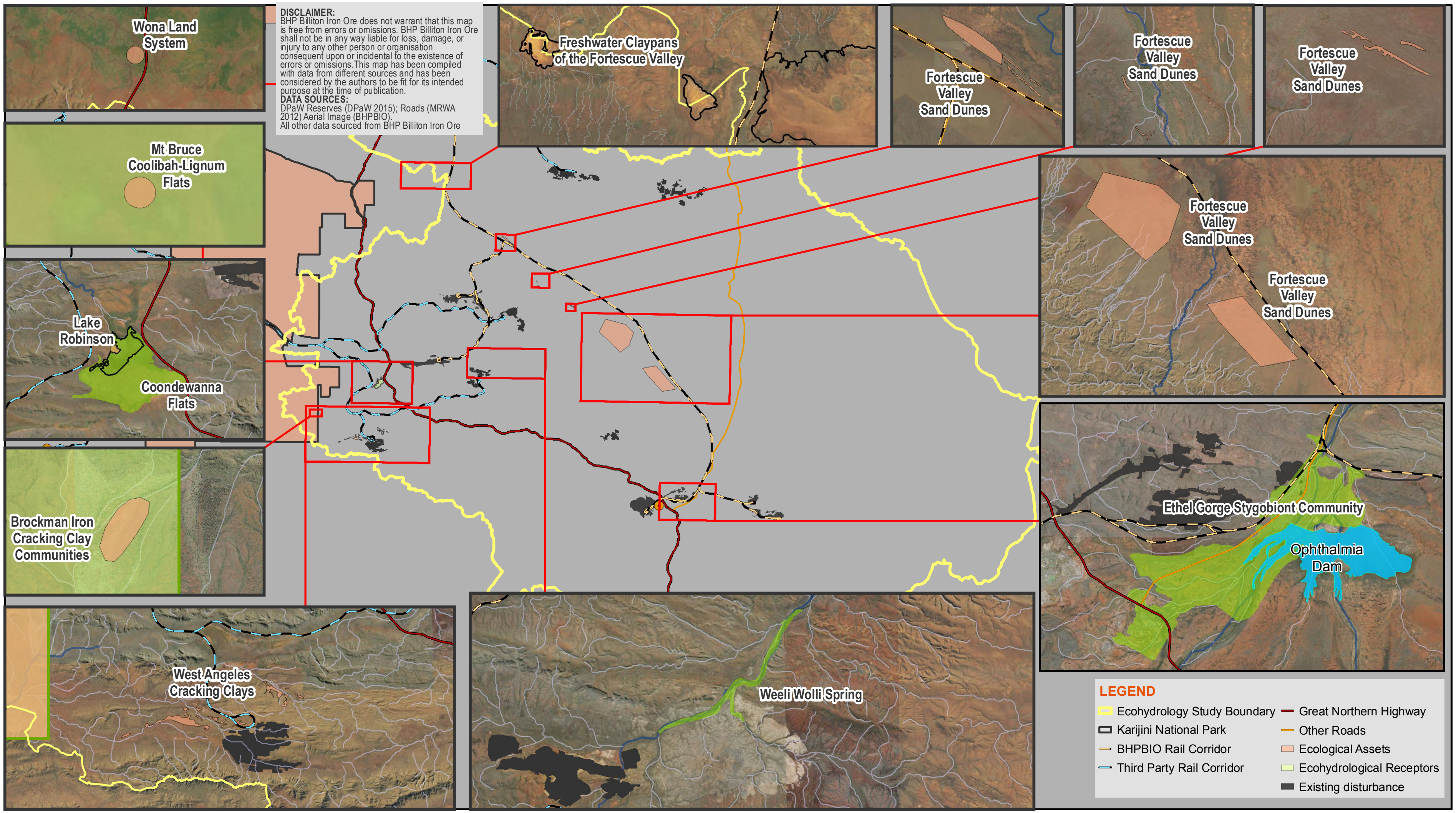
Much of the study area has a low sensitivity rating, and these areas have negligible dependence on water contribution from other landscape elements. Areas of moderate sensitivity are associated with drainage tracts in upland settings. Areas of high sensitivity include the major drainage basins (e.g. the Fortescue Marsh, Coondewanna Flats), the Fortescue River and major creek systems (e.g. Weeli Wolli Creek, Marillana Creek and the various creeks that converge at Ethel Gorge).

Key Ecohydrological Receptors

BHP Billiton Iron Ore undertook a process for identifying and prioritising ecological assets, with those assets protected by law or recognised as having specific conservation significance by an international convention or organisation considered an ecological asset. These assets include but are not limited to wetlands listed in A Directory of Important Wetlands in Australia (Environment Australia 2001), TECs and PECs and national parks. Ecological assets within the Project Definition Boundary were identified through a desktop review of existing policy and processes and current data sources (further details on the method for the identification of ecological assets is provided in Appendix 2.

The ECA (Appendix 7) assessed the ecological assets to determine their ecohydrological connection (360 Environmental 2015). There are six ecological assets that have strong ecohydrological connection with the wider landscape, high ecohydrological sensitivity, and potential for hydraulic connectivity with existing or proposed BHP Billiton Iron Ore operations (Appendix 7). These six ecological assets have been termed ecohydrological receptors and are defined as ecological assets that have hydrological dependency and high sensitivity to groundwater change. The six ecological receptors are described in Table 44 and shown in Figure 48.

Ecohydrological conceptualisation studies have been completed for each of the six ecohydrological receptors, which provide a simplified representation of an integrated hydrological and ecological system, with consideration of the abiotic and biotic processes that control or influence the movement or storage of water and its fate within ecosystems. The intent is to understand and communicate ecohydrological functioning as simply as possible, while retaining sufficient detail and resolution to adequately represent key system elements and their interactions at a landscape scale. The ecohydrological conceptual studies developed as part of the ECA are included as Appendices C to F of Appendix 7.



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Strategic Proposal

Figure 46 Location of ecohydological assets and receptors

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DRAWN: BHP Billiton Iron Ore Environmental Approvals

Table 42: Description of ecohydrological receptors

ECOHYDROLOGICAL RECEPTOR	DESCRIPTION
Coondewanna Flats – Coolibah-lignum Flats PEC	Coondewanna Flats (EHU 6) is a receiving area for surface water runoff from surrounding catchments. Floodwaters accumulate on the flats, replenishing soil moisture in the deep unsaturated profile and contributing to groundwater recharge. Lake Robinson (EHU 9) is the principal drainage terminus within the flats and contributes to groundwater recharge when inundated. The water table lies at 20 to 30 m bgl within an unconfined calcrete aquifer that is overlain by unsaturated Tertiary detritals. Coondewanna Flats supports regionally unusual *Eucalyptus victrix* woodland communities, with two being classified as PECs (Priority 1 and Priority 3). The ecological water requirements of these woodlands are considered to be met by surface water; however, a precautionary approach has been adopted as further studies are required to fully demonstrate and validate any groundwater dependency.
Ethel Gorge Aquifer Stygobiont Community TEC	Ethel Gorge is a zone of confluence of surface water and groundwater flows from the headwaters of the Upper Fortescue River catchment. The Ethel Gorge groundwater system occurs in detrital sediments bound by low-permeability basement rocks. The shallow unconfined aquifer is variably disconnected from a deeper aquifer by an extensive low-permeability clay aquitard. The shallow alluvial and calcrete aquifers of Ethel Gorge support a unique and diverse stygofauna assemblage, the Ethel Gorge Aquifer Stygobiont Community TEC (Endangered). The area supports riparian woodland communities with potential groundwater dependence. Ophthalmia Dam has a strong influence on the hydraulic response of the shallow unconfined aquifer. Since the early 1980s, the dam and associated managed aquifer recharge have resulted in increased groundwater recharge and hydraulic loading to this aquifer. Mine dewatering associated with the nearby Eastern Ridge operations has occurred since 2006. The net effect of disposal of surplus dewatering discharge into Ophthalmia Dam and managed aquifer recharge has resulted in higher groundwater levels in Ethel Gorge than occurred prior to construction of the dam.
Fortescue Marsh - Marsh Land System PEC	Fortescue Marsh, the largest ephemeral wetland in the Pilbara, is an extensive drainage terminus feature occupying approximately 1,000 km^2, which receives surface water inflows from the Upper Fortescue River catchment. The marsh is an important regional conservation asset and supports populations of restricted aquatic and terrestrial invertebrates, threatened vertebrate fauna and Priority flora. It is listed as a Priority 1 PEC and listed in the Environment Australia (2001) Directory of Important Wetlands in Australia. The water regime and water balance are dominated by episodic surface water inflows, with the majority of inflows contributed by the Fortescue River and, to a lesser extent, Weeli Wolli Creek. Numerous smaller drainages from surrounding catchments also flow directly into the marsh. Groundwater discharge is minimal and likely to be spatially restricted.
Freshwater Claypans of the Fortescue Valley PEC	This Priority 1 PEC in the Lower Fortescue River Valley comprises five claypans. The three easternmost claypans are situated close to BHP Billiton Iron Ore's proposed Roy Hill mining area, which is included in the Strategic Proposal. Claypan water regimes are dominated by episodic surface water inflows from surrounding catchments. Interaction with the groundwater regime is poorly understood but is likely to be minimal or negligible. Ecological values include rare vegetation types and diverse aquatic invertebrate assemblages.
Weeli Wolli Spring Community PEC	Weeli Wolli Spring occurs in a zone of confluence of surface water and groundwater flows from the headwaters of the Upper Weeli Wolli Creek catchment. Groundwater is shallow (less than 10 m bgl) and becomes shallower towards the spring. As the

ECOHYDROLOGICAL RECEPTOR	DESCRIPTION
	aquifer thins and narrows towards Weeli Wolli Spring, groundwater flow is concentrated and discharged over near-surface basement as baseflow. The Weeli Wolli Spring Community PEC (Priority 1) supports permanent and persistent pools and riparian woodland communities with a groundwater dependency. The groundwater system supports a diverse stygofauna assemblage. The valley of Weeli Wolli Spring also contains a very rich microbat assemblage. Weeli Wolli Spring is affected by the existing Hope Downs mine (third-party operated). The operators of the Hope Downs mine have implemented measures to artificially maintain the water regime in accordance with Ministerial conditions. Elements of the Weeli Wolli Spring Community PEC also occur at Ben's Oasis, located approximately 20 km upstream and south of Weeli Wolli Spring. At this location, the vegetation is concentrated along a relatively narrow creek channel adjacent to some surface water pools. There is very little documented information about the geology, hydrology, or ecology of this area.
Karijini National Park	Most of the Karijini National Park is situated outside the ecohydrological study area and will be largely unaffected by potential ecohydrological change associated with the Strategic Proposal. A small portion of the national park located in the Ashburton River catchment has the potential to be influenced by dewatering activities at the proposed Mudlark mining area, which is located near the eastern boundary of the national park.

8.2.2.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara that are relevant to surface water, groundwater and ecohydrology and the potential impacts to biodiversity linked to these activities, are listed in Table 43. A brief description of each potential impact is provided.

Table 43: Potential impacts to water resources

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Groundwater drawdown	Groundwater can be abstracted to allow mining of deposits that occur below the groundwater level. Groundwater drawdown is caused by groundwater abstraction and lowers the water table surrounding the area being dewatered (usually an existing or future mine void, or potable water borefield). Lowering of the groundwater table may impact groundwater dependent ecosystems such as groundwater dependent vegetation or stygofauna. Impacts to ecological receptors may be considered direct or indirect depending on the level of complexity associated with the impact. For the purposes of this document, the impact of groundwater drawdown on stygofauna is considered direct, because stygofauna occurs exclusively within a defined area under the water table (refer to Section 8.1.5). Impacts to vegetation that may be potentially groundwater dependent are considered indirect because other impacts from third party mining operations and natural climatic variability create a level of complexity. The impact from groundwater drawdown on ecological receptors is described in Section 8.2.2.4.
Changes to groundwater quality	Changes to groundwater quality may occur through saline intrusion or AMD. For the purposes of this document these impacts are considered as indirect. The potential for saline intrusion is restricted to mine dewatering operations that may influence the saltwater interface within the Fortescue River Valley. The impact from groundwater drawdown on ecological receptors is described in Section 8.2.2.4 Impacts associated with AMD is discussed in Section 8.1.6.

Reduced surface water availability	In some areas, creeks may be realigned to avoid mineral deposits, reducing surface water availability downstream. The presence of pits, OSAs and infrastructure may also interrupt sheet flow in certain areas that may impact of dependent vegetation. Reduced surface water availability is generally considered an indirect impact, due to the complexity of interacting hydrological processes. The hydrological change associated with reduced surface water availability is described in Section 8.2.2.4
Surplus water management	The discharge of water to ephemeral streams for extended periods and in an arid climate can alter the composition of ecological communities associated with these systems and create an unnatural dependency on the water being discharged. The quality of water discharged to the environment has the potential to impact directly on species and communities (discussed below). The discharging of water to surface and through managed aquifer recharge has the potential to waterlog soils and directly affect individuals and communities, but may also mitigate the effects of groundwater drawdown (discussed above). Artificial water bodies (e.g. pit lakes, tailings dams, turkey's-nest dams) can have both a positive and negative impact on biodiversity. For example, increasing the availability of water in an arid climate can promote the growth of weeds and encourage competition between weeds and naturally occurring species and communities. The impacts associated with surface water management are considered indirect impacts for the purposes of this document. Management and mitigation of surface water discharge will be considered on a case-by-case basis subject to proposed engineering design for each future proposal. The ability to mitigate potential impacts to acceptable levels in line with Strategic Proposal conditions will be validated as part of any Derived Proposal referral.
Changes to surface water quality	Changes to surface water quality can occur through contamination associated with inappropriate storage and management of hydrocarbons, or other hazardous goods. Alterations to landforms can lead to increased erosion and deposition of sediments in waterways. Impacts associated with surface water quality are considered indirect impacts for the purposes of this document. Impacts to surface water quality are generally local in scale and therefore have not been assessed further within this document. Management and mitigation of surface water discharge will be considered on a case-by-case basis subject to proposed engineering design for each future proposal. The ability to mitigate potential impacts to acceptable levels in line with Strategic Proposal conditions will be validated as part of any Derived Proposal referral.
Pit lakes	The creation of pit lakes in post-mining landforms may cause a number of impacts, such as the concentration of groundwater or the migration of saline pit water or contaminants into fresh groundwater systems. The impacts associated with pit lakes are considered indirect impacts for the purposes of this document, and are considered further in Section 8.5.2.

8.2.2.3 MITIGATION

BHP Billiton Iron Ore will apply mitigation measures from the Water Management toolkit (Figure 42) to manage impacts to hydrological processes and inland waters environmental quality. A summary of management actions routinely used by BHP Billiton Iron Ore to mitigate the threatening processes identified in Section 8.2.2.2 is provided in Table 44. Specific examples of the mitigation toolkit being implemented in existing and proposed operations are provided in the following case studies.

Table 44: Potential management approaches for water

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Groundwater drawdown	• Undertake *controlled dewatering* to ensure that groundwater drawdown is minimised as far as practicable while meeting operational needs. • Draft and implement *management plans*, including implementing *offsets* where necessary, for key assets and significant species as described in Section 6.2. • Undertake *ecological asset monitoring* where appropriate for ecological receptors in line key assets and significant species management as above. • Establish *performance criteria* to maintain ecological receptors. • Undertake *managed aquifer recharge* or *controlled surface water discharge* where appropriate to mitigate groundwater drawdown.
Changes to groundwater quality	• Undertake *groundwater monitoring* where appropriate to detect changes in groundwater quality to trigger an effective management response.
Reduced surface water availability (indirect)	• *Avoidance* or *minimisation through informed design* by avoiding or minimising clearing of significant flora and vegetation through undertaking *baseline* and *targeted surveys* and, where practicable, altering mine plans to avoid significant flora and vegetation. • Install *surface water diversions* to maintain surface water flow to natural drainage lines and avoid loss of water to the catchment.
Surplus water management (indirect)	• Undertake *weed control* to ensure that the Strategic Proposal does not encourage or exacerbate the spread or presence of weeds. • Implement *water sharing between sites* where applicable to minimise need for excess water disposal.
Surface water quality (indirect)	• Manage water quality where appropriate through *desalination* and installation of *sediment ponds* prior to discharging water to the environment. • Undertake *surface water monitoring* where appropriate to detect changes in surface water quality to trigger an effective management response.
Pit lakes	• Develop appropriate closure strategies in line with the Rehabilitation and Decommissioning Management toolkit (Figure 70).

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

Groundwater and Surface Water Modelling

BHP Billiton Iron Ore routinely undertakes groundwater and surface water modelling to understand the potential impacts that may occur from dewatering activities or alterations to surface water flow to surrounding ecological receptors. The models are regularly validated through such data as test-pumping results, groundwater bore monitoring, and surface water flow and water quality monitoring. Case Study 6 presents an example of the types of activities undertaken to validate and improve through adaptive management the conceptual understanding of mining-related changes to the groundwater and surface water regime at Ethel Gorge, which is an ecological receptor.

Case Study 6: Ethel Gorge surface water and groundwater management

Ethel Gorge is a zone of confluence of surface water and groundwater flows from the headwaters of the Upper Fortescue River catchment. It is located on the Fortescue River about 15 km northeast of Newman. The Ethel Gorge groundwater system occurs in detrital sediments bound by low-permeability basement rocks.

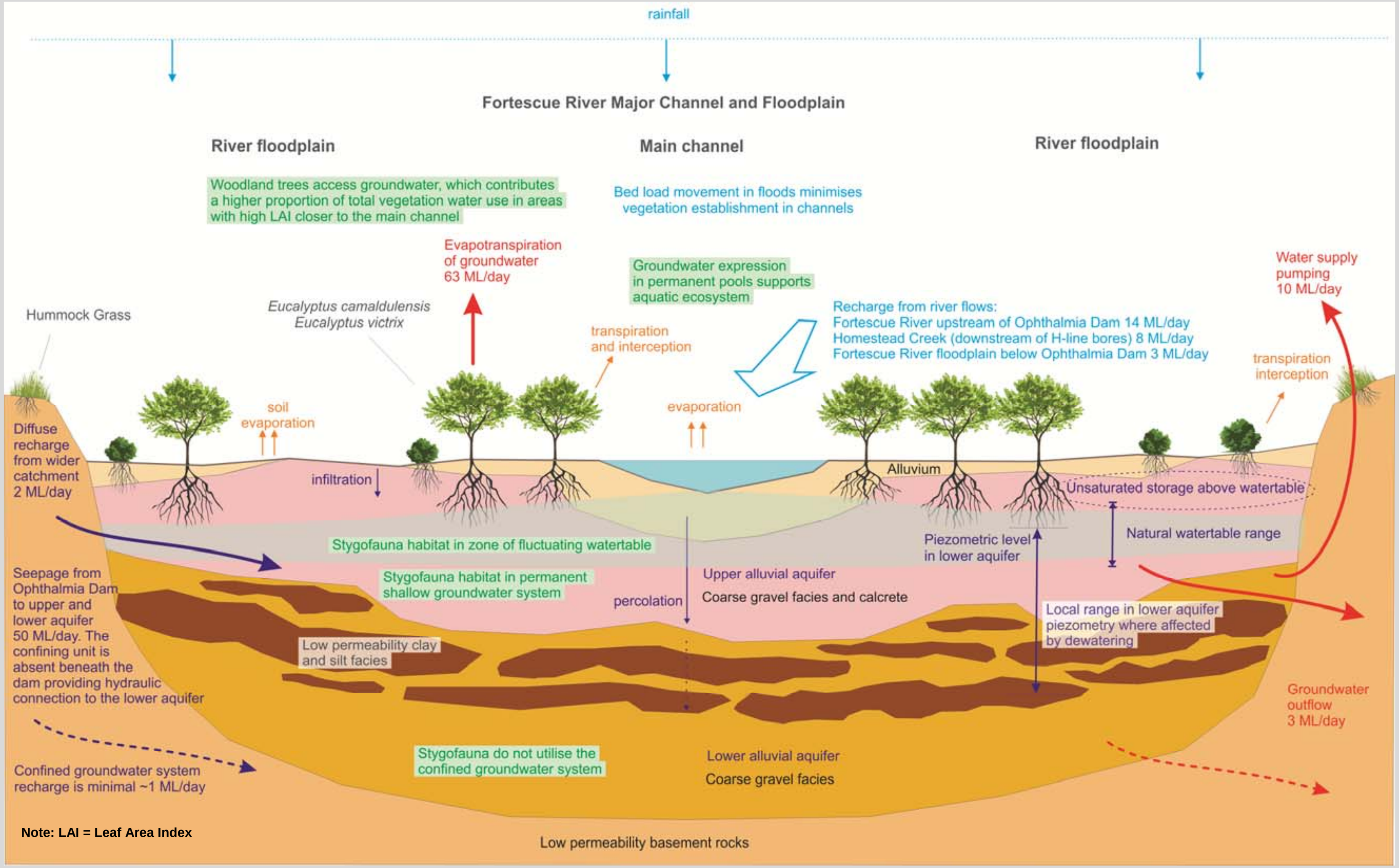
The aquifer hosts the Ethel Gorge stygobiont community, a TEC that contains an abundant and diverse stygofauna community. The Ethel Gorge area also supports riparian woodland vegetation communities, which may be groundwater-dependent. An ecohydrological conceptual model is provided below.

BHP Billiton Iron Ore has a mining lease over Ethel Gorge and owns (and operates) the Ophthalmia Borefield, which is an important water supply for the Newman townsite and the surrounding mining operations. BHP Billiton Iron Ore also owns the Ophthalmia Dam, which is a purpose- designed managed aquifer recharge structure, located about 3 km upstream of Ethel Gorge.

Predictive numerical modelling was carried out to estimate groundwater drawdown associated with the Strategic Proposal and its impact on the Ethel Gorge ecological receptors (RPS 2014a). Numerical modelling suggests that groundwater levels can be sustained throughout the Ophthalmia aquifer, which implies no significant impacts on either the stygofauna community or riparian vegetation associated with groundwater drawdown resulting from the Strategic Proposal. The modelling demonstrates that drawdown in the Ophthalmia aquifer would be offset by leakage from the Ophthalmia Dam and infiltration along the recharge ponds. The numerical model also suggests that rising groundwater levels, caused by increased infiltration from the discharge of surplus water to Ophthalmia Dam and associated infiltration infrastructure, will remain within the historical range during implementation of the Strategic Proposal.

The water and salt balance modelling shows that, for the majority of the Ophthalmia aquifer and the majority of climatic and operating conditions, salinity concentrations will remain within the historical (between 1977 and 2014) recorded ranges. However, salinity concentrations could increase to about 30% above historical maximum ranges for lower than normal rainfall conditions (RPS 2014b). The operating strategy of the dam is predicted to exert a strong influence on groundwater salinity concentrations. In particular, salinity concentrations could be 70% above historical maximum ranges if water is released from the dam during non-flooding periods. Available scientific knowledge suggests that many stygofauna species can tolerate a variable salinity regime (Halse et. al. 2014). However, less resilient species may be vulnerable to salinity increases beyond the range of natural variability. Riparian vegetation communities are considered unlikely to be significantly affected by increases in groundwater salinity concentrations because the vegetation principally relies on soil moisture. Technical studies are being progressively undertaken to contribute to the understanding of the system.

The modelling suggests that, upon closure, groundwater levels in the Ophthalmia aquifer will recover within a couple of years after groundwater abstraction ceases, which implies no significant impacts on the Ethel Gorge stygofauna community and riparian vegetation after closure. The apparent hydraulic disconnection between the mine pits and the Ethel Gorge groundwater system suggests that the closure strategy to retain open pits will have no significant effect on groundwater levels in the Ophthalmia aquifer. However, the degree of hydraulic disconnection will be validated through ongoing groundwater monitoring. Because Ethel Gorge is a TEC, it is considered a Tier 1 Asset (refer to Section 6.2) for the purposes of management. Performance criteria consisting of early warning triggers and thresholds have been selected to ensure that monitoring is targeted to key hydrological change processes. In the early stages of the process, these triggers and thresholds are typically conservative and precautionary, reflecting incomplete scientific knowledge. As scientific understanding becomes more complete, the level of uncertainty reduces and management thresholds can be refined.



Ethel Gorge ecohydrological conceptualisation

Groundwater modelling is a key component of the Water Management Toolkit (Figure 42), which allows for prediction of potential impacts well in advance of operational dewatering. It also allows appropriate triggers and thresholds to be developed to ensure that impacts to this Tier 1 asset are managed to an acceptable level.

Managed Aquifer Recharge

BHP Billiton Iron Ore has established managed aquifer recharge at Ophthalmia Dam and Marillana Creek and has begun trials for managed aquifer recharge at Jimblebar and Mining Area C (refer to Case Study 7). Trials have shown that managed aquifer recharge is an effective tool for managing surplus water from mine dewatering.

Case Study 7: Managed Aquifer Recharge at Mining Area C

BHP Billiton Iron Ore currently operates Mining Area C, located approximately 120 km northwest of Newman. Mining Area C is located in a tributary drainage of the Weeli Wolli Creek catchment.

The managed aquifer recharge trial (the trial) at Mining Area C has involved injecting surplus water generated from the dewatering operations of orebodies into existing production bores. The intent of the trial was to enable an assessment of the overall feasibility and long-term sustainability of a managed aquifer recharge operation at Mining Area C and, more generally, for similar hydrogeological settings in the central Pilbara region. The key areas of investigation throughout the period were:

- hydraulic performance of the injection wells and receiving aquifers;
- extent of groundwater mounding along strike and across strike, within the context of the site conceptual hydrogeological model;
- magnitude and extent of resaturation and repressurisation of individual lithologies of the mine sequence, with particular focus on affects to pit wall stability;
- hydrogeochemistry (monitoring the effects and extent of mixing); and
- practicality and efficiency of injection infrastructure.

The trial indicated that managed aquifer recharge reduced Mining Area C’s water footprint by returning water to the aquifer and offsetting dewatering impacts by ‘banking’ water for future use for water supply. Under the current injection regime, groundwater mounding can be successfully managed at aquifer scale.

The application of learnings from the trial to other managed aquifer recharge operating conditions with similar geology, design, chemistry and operation is feasible; and the central Pilbara region provides a number of suitable settings. When encountered, the Paraburdoo dolomite can be karstic and is similarly overlain by detrital cover, with comparable (or greater) unsaturated thickness providing similar mounding capacity and injection rates. Groundwater quality is mostly representative of low electrical conductivity and total dissolved solids; thus, clogging has not interfered with bore performance and is not foreseen as a significant future managed aquifer recharge issue.

A net 5-m groundwater rise has occurred as a result of the trial, which has been confined within the Mining Area C area and has not had any influence on the regional groundwater regime. Water level rise due to injection is largely masked by the drawdown from Mining Area C’s dewatering activities and potentially from the Hope Downs operations. There is insufficient data to provide conclusive analysis on the extent and effects of hydrochemical mixing surrounding injection bores; however, the injection bores themselves have shown an improvement in water quality (decrease in solute concentration) as a result of reinjection.

Overall, the trial to date provides confidence that reinjection is a feasible surplus water management strategy for Mining Area C; and the karstic dolomite overlain by Tertiary detritals provides an appropriate receptor in the central Pilbara area. Surplus water management strategies will continue to play a key part in Mining Area C’s future, and BHP Billiton Iron Ore will continue to consider managed aquifer recharge as a key tool for water management.

Water Monitoring

Water monitoring is undertaken across BHP Billiton Iron Ore's operations to validate predictive modelling. Case Study 8 provides an example of the types of monitoring activities undertaken.

Case Study 8: Water Monitoring at Jimblebar

Water monitoring at Jimblebar is undertaken in accordance with a licence issued by the Department of Environment Regulation (DER) and within the framework of a site-specific groundwater operating strategy. A summary of activities includes:

- quarterly hydrochemistry samples of all active production bores, reinjection bores and discharge locations. As the bores are used for potable supply, understanding in detail the composition of the waters helps to be sure that they are safe to drink;
- managed aquifer recharge monitoring, which involves weekly electrical conductivity (EC) and pH sampling for a selection of monitoring bores near reinjection bores and quarterly sampling of hydrochemistry from a slightly smaller selection of monitoring bores plus the reinjection bores themselves;
- measurement of any excess surface water discharge for EC, pH and total suspended solids to ensure compliance with guidelines and licence conditions; and
- field samples from Innawally Pool on a weekly basis to support the DER and DoW requirements (although it is not specified as part of an approval, this information provides excellent contextual data).

Source: BHP Billiton Iron Ore.
Plate: Water monitoring

To ensure licence approvals are met, the following activities are undertaken at Jimblebar:

- monitoring data collection, collation, verification and entry to databases;
- groundwater well licence renewals and preparation and submission of GWL-related reporting and communication of unexpected results;
- prediction and execution of short-term (less than 2-year) and mid- to long-term dewatering requirements and development of water management alternatives; and
- maintenance and day-to-day operation of the borefield, including undertaking regular water supply system leak checks.

8.2.2.4 SIGNIFICANCE OF IMPACTS

The primary basis for the EPA's determination of the likely significance and acceptability of a proposal is whether it is likely to meet the EPA's objectives for each environmental factor. The EPA uses a significance framework to determine the likely significance of a proposal and to make decisions throughout the environmental impact assessment process, as outlined in EPA Environmental Assessment Guideline No. 9 (EPA 2015b). If the EPA considers that a proposal can meet all of its objectives, then the proposal is considered unlikely to have a significant impact on the environment. If the EPA considers that a proposal may or may not meet one or more of the EPA's objectives, then its impact on the environment is considered likely to be significant. If the EPA considers that a proposal is unlikely to meet one or more of its objectives, then its effect on the environment is likely to be unacceptable.

In analysing impacts to the environment from this Strategic Proposal, BHP Billiton Iron Ore has applied the EPA's significance framework to determine whether the proposal can meet the EPA objectives for each environmental factor. For the purposes of evaluating significance, water-related impacts informed by Position Statement No. 4: Environmental Protection of Wetlands (EPA 2004c). This position statement contains principles to assist and enable a variety of natural resource managers, decision-makers and land owners to restore, maintain or enhance the environmental values and beneficial uses of wetland ecosystems within the context of an overall goal of no net loss of wetland values and functions.

The Ecohydrological Change Assessment (Appendix 7) outlines the potential for the Strategic Proposal to influence the hydrological regime of landscapes and ecohydrological receptors for three development scenarios:

- Baseline: Existing Development Scenario based on actual production rates (as at September 2014);
- 30% Conceptual Development Scenario: Development scenario based on the production rate associated with approximately 30% of BHP Billiton Iron Ores future identified projects being in concurrent operation; and
- Full Conceptual Development Scenario: Development scenario based on the production rate associated with full conceptual development of BHP Billiton Iron Ores future identified projects and these projects being in concurrent operation.

The influence of third-party mining operations was also considered, providing an indication of baseline and cumulative change potential. It was assumed that third-parties would comply with existing Ministerial Conditions.

Impact to Surface Water

In the baseline scenario, there is only a minor (less than 5%) potential change in surface water availability for all EHUs associated with BHP Billiton Iron Ore only across the ecohydrological study area. The EHUs that may change are low-sensitivity upland units (EHUs 1 and 2) and moderate-sensitivity transitional units (EHUs 3 and 4) of the eastern Pilbara and central Pilbara regions. Regional change potential related to third-party operations at 2014 is most apparent in the moderate-sensitivity transitional units (EHUs 3 and 4) and low-sensitivity lowland alluvial plains unit (EHU 6) in the central Pilbara region. EHUs in the Fortescue Marsh region are subject to negligible change relative to the size of the Fortescue River Valley catchment.

For the 30% Conceptual Development Scenario, there are increasing areas of cumulative surface water reduction (Figure 47). These areas include the northern and southern flank of the Fortescue River Valley, Marillana Creek, drainages that flow towards Weeli Wolli Creek, surrounding catchment of Coondewanna Flats and drainages that contribute to Ethel Gorge.

For the 30% Conceptual Development Scenario, further reduction in surface water availability by BHP Billiton Iron Ore is observed in some units in the central Pilbara region and calcrete areas associated with the proposed Munjina and Upper Marillana mining areas and with the receiving drainage areas at Ethel Gorge, Marillana Creek and Weeli Wolli Creek. The potential change associated with third-party operations is pronounced in some units in the Fortescue Marsh region, Ethel Gorge, Marillana Creek and Weeli Wolli Creek and within the Central Pilbara.

Cumulative surface water reductions increase (Figure 48) without mitigation for the Full Conceptual Development Scenario. Key areas of change include the northern flank of the Fortescue River Valley, lower

Weeli Wolli Creek, catchment areas surrounding Coondewanna Flats, and drainages that contribute flows to Ethel Gorge.

Without the application of mitigation measures, the potential reduction in surface water availability related to the Strategic Proposal is significant. The potential change in EHUs is most apparent in some units in the central Pilbara, Fortescue Marsh and Marillana Creek regions, at Ethel Gorge, Marillana Creek itself and Weeli Wolli Creek. Without mitigation, a significant cumulative change is observed in the high-sensitivity, lowland receiving (drainage termini) area (EHU 9) associated with the Fortescue Marsh.

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact certain parts of the landscape through impacts to surface water as described above if appropriate mitigation is not implemented. The above predictions highlight the mitigation considerations for EHUs, which are described in Box 3.

Box 3: Regional level management considerations for EHUs

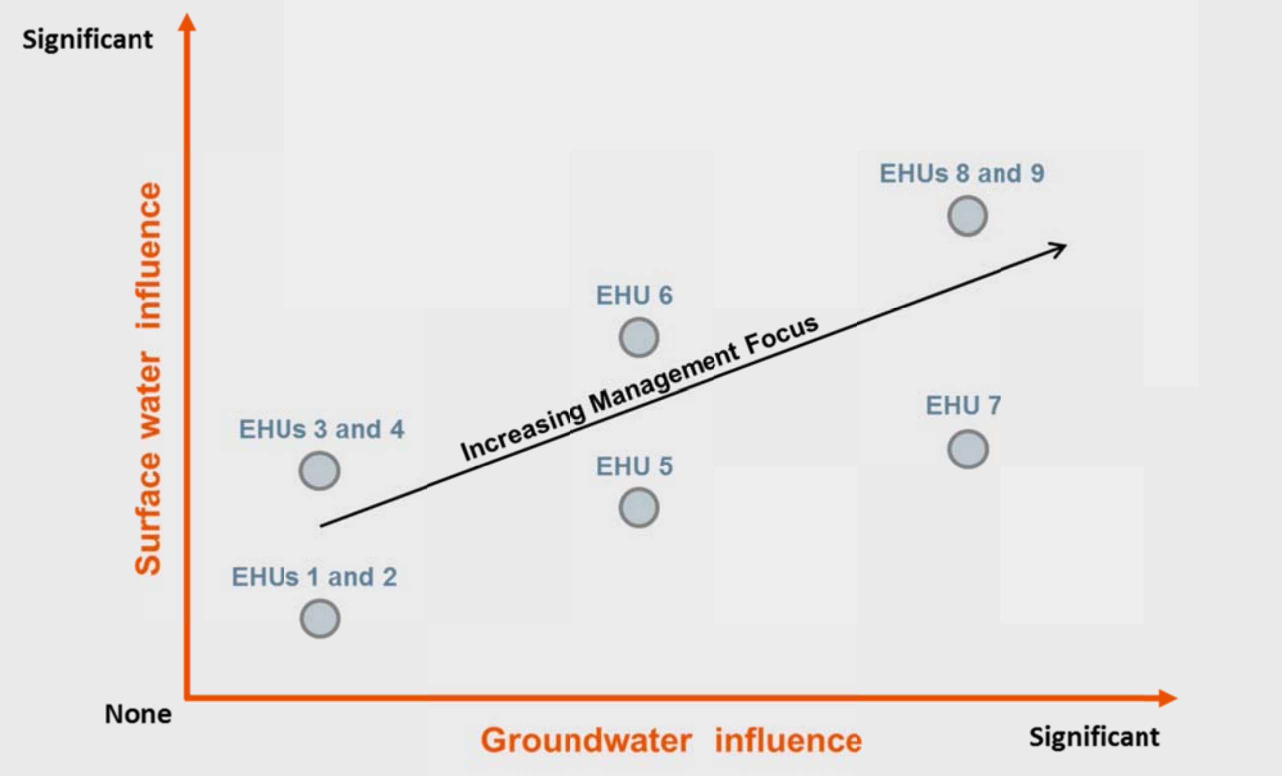
The landscape conceptualisation based on EHUs provides a useful framework for considering regional-scale management approaches that address hydrological processes and inland waters environmental quality. For each EHU, a common set of management themes linked to the surface water regimes, groundwater regimes and ecological components within the EHU can be identified. The relative importance of particular management aspects across all of the EHUs can also be evaluated.

A higher level of management focus is anticipated for areas corresponding with EHU 7, 8 and 9 owing to the direct dependency of ecosystems in these areas on water influx from the surrounding landscape, and also the potential for surface and groundwater interactions (see figure below). Further discussion of the major water management considerations for individual EHUs is provided below.

EHU 1 and 2: Terrestrial ecosystems are rain-fed and disconnected from groundwater. The focus of management is to maintain surface runoff from source areas including drainage pathways into EHUs 3 and 4 and their downstream connectivity to EHU 8. This is achievable using normal business management practices. No requirement for groundwater level management.

EHU 3 and 4: Terrestrial ecosystems rely on surface water inputs and are disconnected from groundwater. The focus of management is to maintain the ephemeral surface water flow regime in drainage lines, including the passage of flow into downstream areas and associated soil profile moisture replenishment processes. Use creek diversions for surface water management. This is achievable using normal business management practices. No requirement for groundwater level management. Surplus water management in accordance with options under the Water Management Toolkit (Figure 42) may be required.

EHU 5: Terrestrial ecosystems that are predominantly rain-fed and disconnected from groundwater, but there are localised areas that receive surface water flow from up-gradient. Zones of deep, sandy soil profiles may facilitate higher rates of groundwater recharge compared with surrounding landscapes. The focus of management is to maintain the ephemeral surface water flow regime. This is achievable using normal business management practices.



EHU 6: Terrestrial ecosystems rely on surface water inputs and are predominantly disconnected from groundwater. Significant local scale redistribution of surface water may occur in these areas, as influenced by topographic and vegetation patterns. The focus of management is to maintain and preserve patterns of surface water flow, and allow sheetflow and channel flow pathways to remain open. This is achievable using normal business management practices. Management and monitoring discharge of surplus mine dewatering. Generally no requirement for groundwater level management, however case specific exceptions at a local scale may occur (for example where relevant for aquifer recharge processes). Surplus water management in accordance with options under the Water Management Toolkit (Figure 42) may be required.

EHU 7: Terrestrial ecosystems rely on surface water inputs and are predominantly disconnected from groundwater. Significant local scale redistribution of surface water may occur in these areas. Zones of karstic calcrete where runoff accumulates may facilitate higher rates of groundwater recharge compared with surrounding landscapes. Karstic groundwater systems are considered to have high stygofauna habitat values. The focus of management is the preservation of recharge mechanisms and stygofauna habitat. Enable flows from upgradient to continue reaching calcrete area to maintain surface water to groundwater linkages. Watertable control in calcrete aquifers to preserve adequate habitat for stygofauna; as such approaches for mitigating drawdown effects (e.g. MAR) may be applicable. Surplus water management in accordance with options under the Water Management Toolkit (Figure 42) may be required.

EHU 8: Riparian ecosystems rely on the surface water flow regime, and in some places interact with groundwater via recharge and/or discharge processes. At a regional scale EHU 8 includes important zones of concentrated recharge. The focus of management is the preservation of the water balance and water quality. Local area management plans developed may be required. Large surface water flows have the potential to impact on infrastructure in major floods. Permit and maintain drainage pathways - avoid obstruction of drainages. Maintain and allow streamflow over aquifers to enable recharge. Manage and monitor discharge of surplus mine dewatering. Monitor and maintain water levels in riverine pools and other areas of high surface water and groundwater connectivity. Watertable control is important as ecosystems may be prone to groundwater drawdown influence. Monitor and appreciate variability in water levels, and consider mitigations to maintain the water balance as required - a form of MAR and/or augmentation of soil moisture, into pools etc. may be applied.

EHU 9: Terminal areas for surface water flows, which may include zones of concentrated recharge and/or discharge. Vulnerable to changes in the water balance from modifications to surface inflows and the watertable. The focus of management is the preservation of the water balance and water quality. Local area management plans may be required. Seek to maintain the magnitude and frequency of inundation. Monitor sediment accumulation. Monitor the potential for salinity increases in waterbodies over time. Watertable control is important as ecosystems may be prone to groundwater drawdown influence. Recognise that areas can be groundwater recharge and discharge areas, which will dictate appropriate management approaches. Monitor and appreciate variability in water levels, and consider mitigations to maintain the water balance as required – this may involve a form of MAR and/or augmentation of soil moisture and/or into pools.

Impacts to EHUs will be validated at the Derived Proposal stage and the above water management considerations will be taken into account and refined based on site specific information such as mine design and scheduling and updates to baseline knowledge in line with the adaptive management approach.

BHP Billiton Iron Ore considers that impacts to surface water can be managed to an acceptable level through normal business management practices or though targeted management through measures identifies in the Water Management Toolkit (Figure 42). Impacts to key ecohydrological receptors are discussed further within this section.

Impact to Groundwater

Groundwater drawdown

In the Existing Development Scenario, areas of ecohydrological change potential associated with groundwater drawdown are spatially restricted, with little interaction between operations. Groundwater drawdown is most pronounced in the EHUs with the least sensitivity to groundwater change, namely the upland (EHUs 1 and 2) and transitional (EHUs 3 and 4) units of the eastern Pilbara and central Pilbara regions.

For the 30% Conceptual Development Scenario, groundwater drawdown has expanded from the Existing Development Scenario, with increased areas of cumulative drawdown linked to multiple operations (Figure 49). The increasing cumulative groundwater drawdown produces noticeable change in depth to groundwater in the least sensitive upland (EHUs 1 and 2) and transitional (EHU 3 and 4) units within the central Pilbara and Fortescue Marsh regions.

The EHUs with the greatest groundwater drawdown (at Existing Development and in the 30% Conceptual Development Scenario) are not considered to support groundwater-dependent communities, and drawdown is not expected to result in the loss of groundwater-dependent ecosystems.

For the Full Conceptual Development Scenario, the unmitigated groundwater drawdown may be relatively extensive, with proposed BHP Billiton Iron Ore mining operations significantly contributing to cumulative drawdown (Figure 50). The areas of potential change in EHUs related to groundwater drawdown are most apparent in units in the central Pilbara, Fortescue Marsh, and Marillana Creek regions and Weeli Wolli Creek (EHUs 3, 4, 6 and 8).

Groundwater Resources

Without mitigation in place, the change in groundwater resources associated with BHP Billiton Iron Ore only for the period between Existing Development and the 30% Conceptual Development Scenario is less than 5%. Cumulative change (i.e. BHP Billiton Iron Ore and third parties) for the period between Existing Development and the 30% Conceptual Development Scenario is less than 20% without mitigation. The most prominent areas of potential storage depletion occur in the central Pilbara and Marillana Creek regions. Storage depletion is negligible in the eastern Pilbara region owing to the influence of Ophthalmia Dam and in the Fortescue Marsh region owing to the large stored groundwater resource within the Fortescue River Valley.

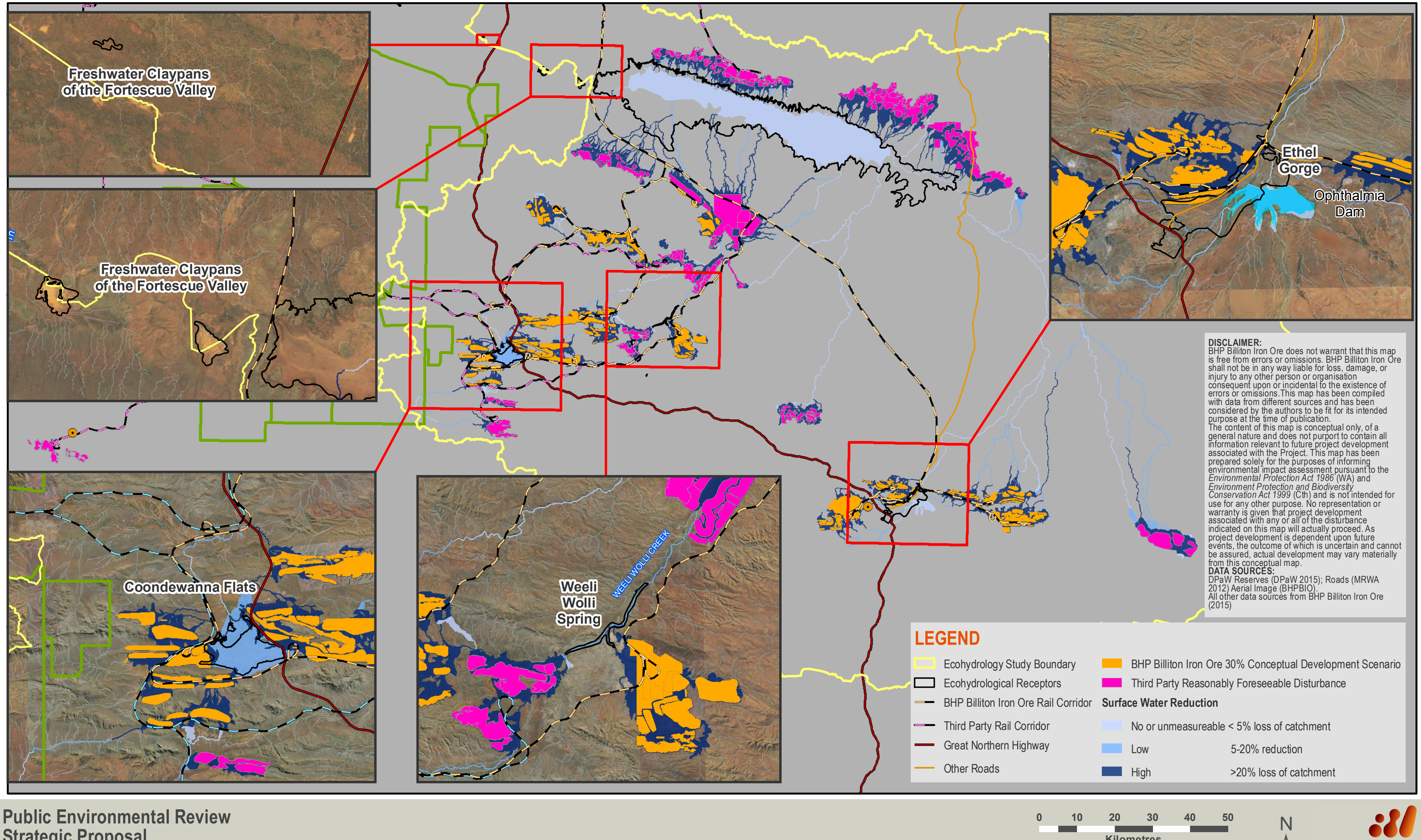


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Figure 47 Surface water availability cumulative - 30% Conceptual Development Scenario

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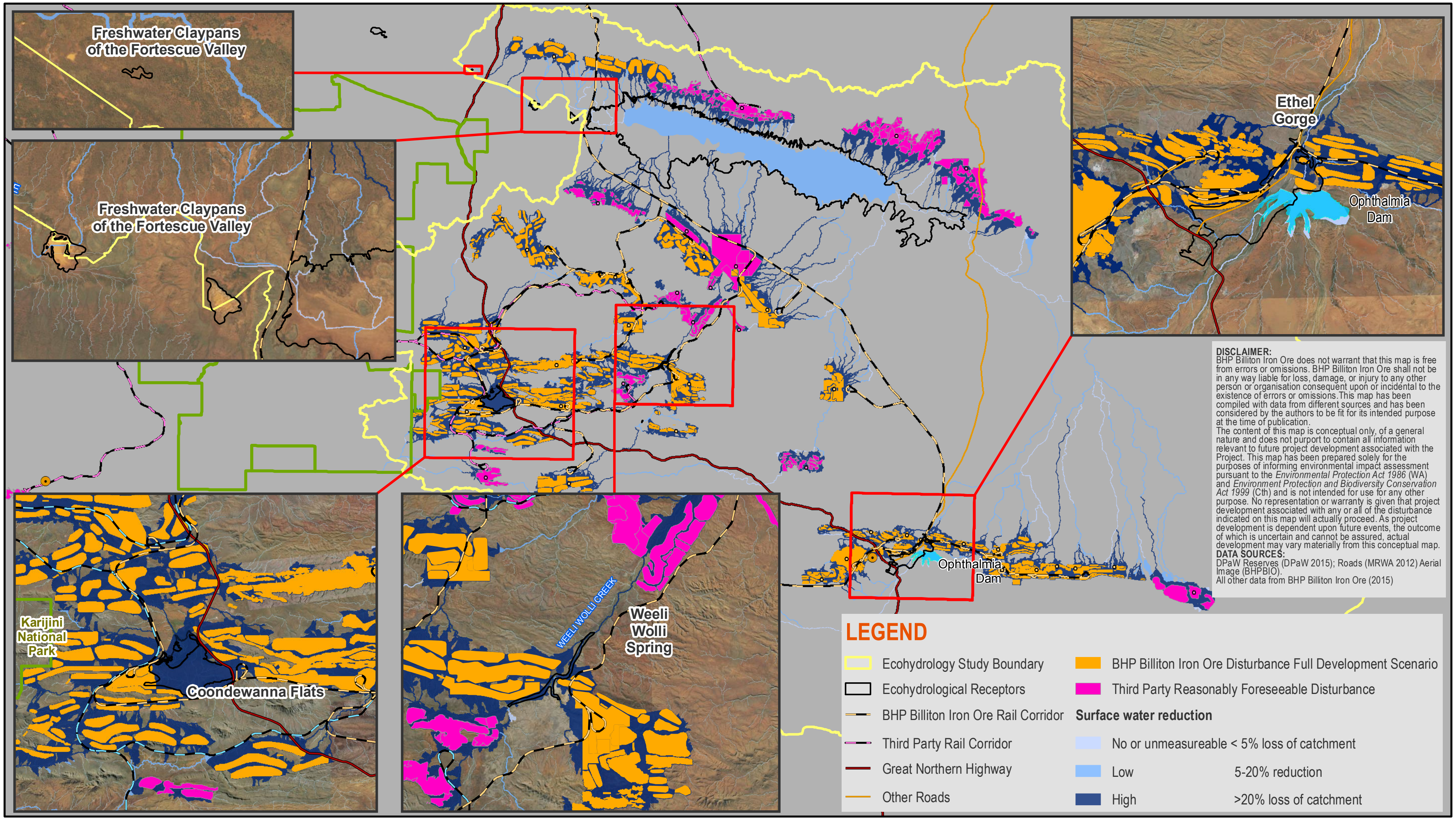

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Figure 48 Surface water availability cumulative - Full Conceptual Development Scenario

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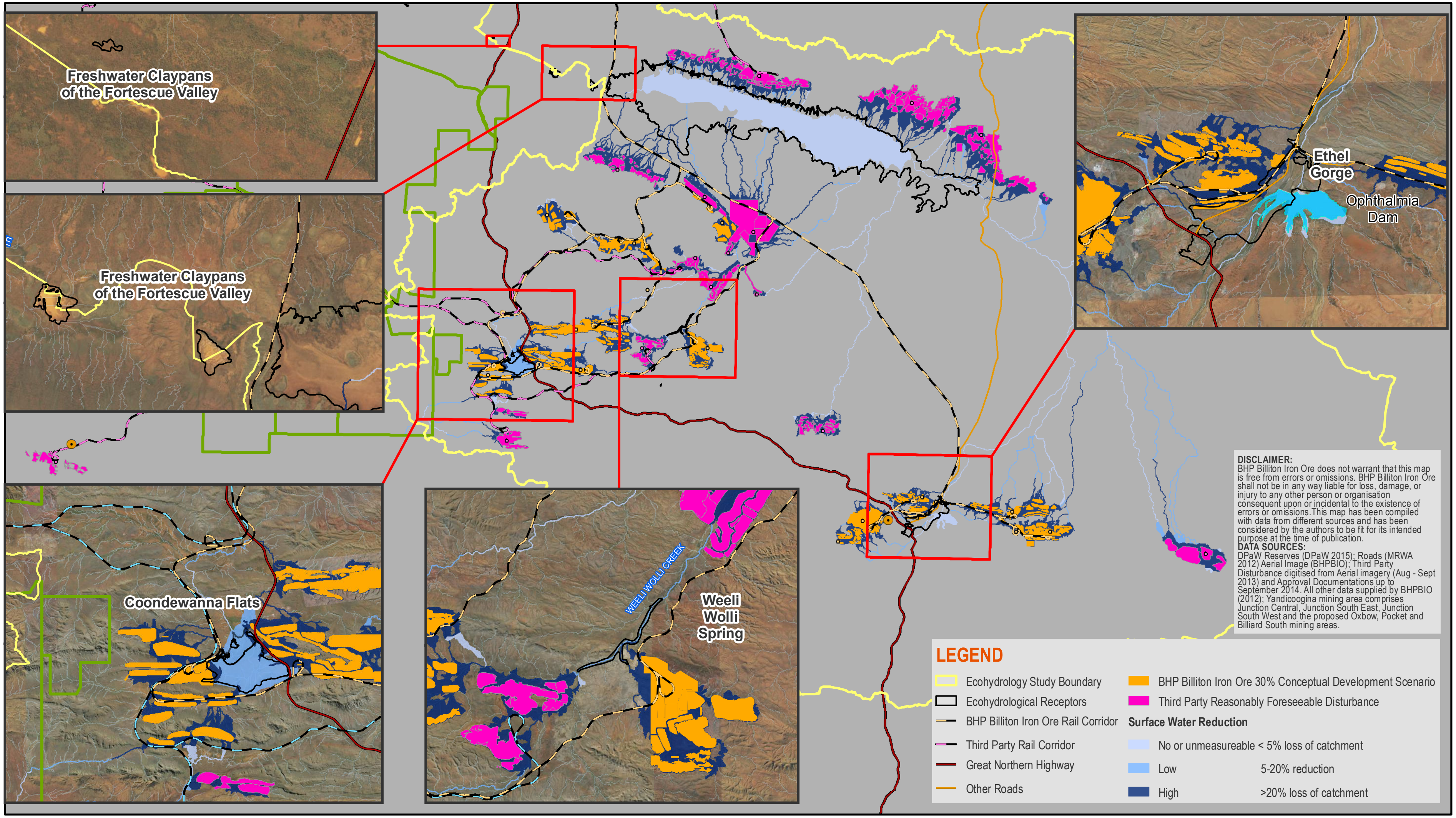

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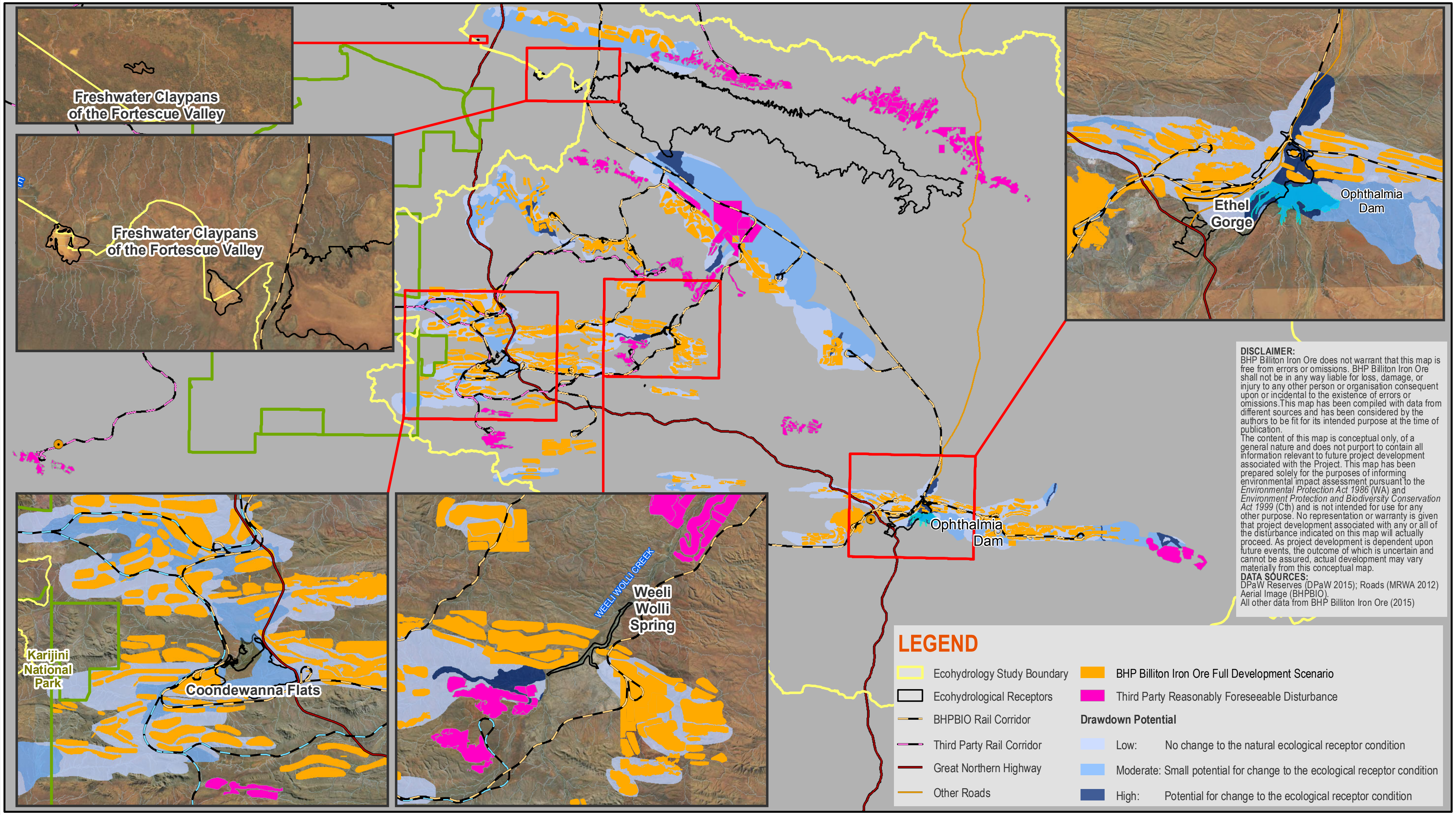
Figure 49 Surface water availability cumulative - 30% Conceptual Development Scenario



DISCLAIMER:
BHP Billiton Iron Ore does not warrant that this map is free from errors or omissions. BHP Billiton Iron Ore shall not be in any way liable for loss, damage, or injury to any other person or organisation consequent upon or incidental to the existence of errors or omissions.This map has been compiled with data from different sources and has been considered by the authors to be fit for its intended purpose at the time of publication.
The content of this map is conceptual only, of a general nature and does not purport to contain all information relevant to future project development associated with the Project. This map has been prepared solely for the purposes of informing environmental impact assessment pursuant to the *Environmental Protection Act 1986* (WA) and *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and is not intended for use for any other purpose. No representation or warranty is given that project development associated with any or all of the disturbance indicated on this map will actually proceed. As project development is dependent upon future events, the outcome of which is uncertain and cannot be assured, actual development may vary materially from this conceptual map.
DATA SOURCES:
DPaW Reserves (DPaW 2015); Roads (MRWA 2012)
Aerial Image (BHPBIO).
All other data from BHP Billiton Iron Ore (2015)

Figure 50 Groundwater availability cumulative - Full Conceptual Development Scenario

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Without mitigation, cumulative change for the Full Conceptual Development Scenario is less than 40%, and this depletion reflects the development of significant new third-party operations.

Groundwater Quality

The greatest potential for saline intrusion is in the Fortescue Marsh region and is associated with mine dewatering in the Marillana, Mindy and Coondiner mining areas. The influence of saline intrusion on the southern side of the Fortescue River Valley for the Existing Development, 30% Conceptual Development Scenario and Full Conceptual Development Scenario is likely to be complicated by cumulative drawdown effects associated with multiple mining projects, including third-party operations (i.e. Brockman Resources' Marillana Project and FMG's Nyidinghu Project). More detailed investigations are necessary to gain a greater appreciation of the interaction between groundwater drawdown extents for the individual operations.

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact certain parts of the landscape through impacts to groundwater as described above if appropriate mitigation is not implemented. The above modelled outcomes highlight the focus for mitigation for each EHU, which are described in Box 3.

BHP Billiton Iron Ore considers that impacts to groundwater can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Water Management Toolkit (Figure 42). BHP Billiton Iron Ore has a proven track record of implementing water management measures to manage impacts to an acceptable level (see Case Study 6, Case Study 7 and Case Study 8). Impacts to key ecohydrological receptors are discussed further within this section.

Impact to Key Ecohydrological Receptors

The findings of the regional ECA were augmented by more focused analysis of the potential for ecohydrological change at each of the six ecohydrological receptors that may be influenced by the Strategic Proposal. The receptor level assessment considers the potential effects of threatening processes for BHP Billiton Iron Ore operations in Existing Development (baseline) and proposed BHP Billiton Iron Ore operations for the conceptual 30% Conceptual Development Scenario and Full Conceptual Development Scenario. The influence of third-party mining operations was considered for each scenario to provide an indication of pre-existing and cumulative change potential. The assessment utilises the ecohydrological conceptualisations.

A summary of the findings of the receptor-level ECA is provided in Table 45, with additional discussion related to each receptor provided in Appendix 7. The potential impacts shown in Table 45 are based on post-mitigation for the Existing Development Scenario, post-mitigation for future third-party mines (this is assuming compliance with conditions such as Ministerial Statements) and premitigation for BHP Billiton Iron Ore future projects.

As provided in Table 45, the ECA predicts a high level of ecohydrological change some ecological receptors at the time the Full Conceptual Development Scenario is implemented, if mitigation is not in place. Receptor-specific environmental outcomes (refer to Section 4.2.1.2) will be developed in consultation with relevant DMAs (as outlined in Chapter 13). Validation as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet these outcomes. Examples of receptor-specific management considerations are outlined below:

- Coondewanna Flats:
    - Groundwater levels and surplus water - surplus water from the Mining Area C mining area may be returned to the groundwater system where practicable and appropriate. The use of MAR may minimise the spatial extent of groundwater drawdown.
    - Validation and refinement of the current ecohydrological conceptualisation for Coondewanna Flats; including the contribution of groundwater to vegetation water use.
    - Validation of potential land surface modifications/catchment reduction on the hydrological regime at Coondewanna Flats.

Table 45: Summary of change potential to key ecohydrological receptors

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Coondewanna Flats (Coolibah-lignum Flats PEC Subtypes 1 and 2 - Tier 2 Asset)				
Existing Development	Cumulative	None	Negligible	Excess dewatering from Mining Area C.
30% Conceptual Development	BHP Billiton Iron Ore only	Moderate. Small area of drawdown from Mining Area C reaches northern extent of receptor.	Moderate. Aggregate catchment reduction from Mining Area C, South Flank and Mudlark.	n/a
	Third-party only	None	None	None
	Cumulative	n/a	n/a	Change potential is only related to BHP Billiton Iron Ore's operations.
Full Conceptual Development	BHP Billiton Iron Ore only	Moderate. Drawdown from Mining Area C, South Flank and Mudlark.	High. Aggregate catchment reduction from Mining Area C, South Flank, Mudlark and Tandanya.	Tandanya has a moderate AMD potential.
	Third-party only	None	None	None
	Cumulative	n/a	n/a	Change potential is only related to BHP Billiton Iron Ore's operations.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Ethel Gorge (Ethel Gorge Aquifer Stygobiont Community TEC – Tier 1 Asset)				
Existing Development	Cumulative	Moderate but change potential offset by infiltration from Ophthalmia Dam. Residual change is low.	None. Minor (less than 5%) catchment reduction from Eastern Ridge.	Slight increase in salt loads due to excess dewatering water discharged to Ophthalmia Dam, but salinity likely to remain within historical ranges (see Case Study 8). Mt Whaleback mine has high AMD source potential with AMD from overburden storage areas being currently managed via collection and treatment.
30% Conceptual Development	BHP Billiton Iron Ore only	High at Orebody 37, but change potential is offset by infiltration from Ophthalmia Dam. Modelling indicates residual change is low.	Moderate. Catchment reduction associated with Eastern Ridge.	Slight increase in salt loads due to excess dewatering discharged to Ophthalmia Dam, but salinity likely to remain within historical ranges (see Case Study 6). Mt Whaleback mine has high AMD source potential, with AMD from overburden storage areas being currently managed via collection and treatment.
	Third-party only	None	None	None
	Cumulative	n/a	n/a	Change potential is only related to BHP Billiton Iron Ore's operations.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Ethel Gorge (Ethel Gorge Aquifer Stygobiont Community TEC – Tier 1 Asset) (cont'd)				
Full Conceptual Development	BHP Billiton Iron Ore only	High from Orebody 37, but change potential is offset by infiltration from Ophthalmia Dam. Modelling indicates residual change is low.	High. Catchment reduction from Eastern Ridge, Jimblebar and East Ophthalmia.	Predicted (modelled) increase in salt loads due to discharge of excess dewatering water to Ophthalmia Dam from various operations. Mt Whaleback mine has high AMD source potential and will likely form a groundwater sink after closure with no connection to Ethel Gorge. Note: the Ethel Gorge case study (Case Study 6) considers that groundwater salinity is likely to be within the tolerance thresholds of the stygofauna community and that there is no significant risk of impact to riparian vegetation given appropriate operation of Ophthalmia Dam.
	Third-party only	None	None	None
	Cumulative	n/a	n/a	Change potential is only related to BHP Billiton Iron Ore's operations.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Fortescue Marsh (Marsh Land System) PEC – Tier 2 Asset				
Existing Development	Cumulative	None. Drawdown change potential from FMG's Christmas Creek and Cloudbreak operations managed by MAR.	None. Low change potential restricted to local drainages north of the marsh due to reduced catchment from FMG mining areas.	Excess dewatering from FMG's Christmas Creek and Cloudbreak mining areas is managed by MAR. The excess dewatering volumes include both fresh and hypersaline water.
30% Conceptual Development	BHP Billiton Iron Ore only	None. Only above water table mining at Marillana.	None. Moderate to high change potential in local drainages only, owing to reduced catchment from Marillana.	None
	Third-party only	None. Drawdown change potential from FMG's Christmas Creek and Cloudbreak operations managed by MAR.	None. Low to moderate change potential in local drainages in the marsh area owing to reduced catchment from third-party mining areas.	Excess dewatering (saline and fresh) from FMG's Christmas Creek and Cloudbreak mining areas managed by MAR. Other third-party operations (Brockman Resources' Marillana, FMG's Nyidinghu and Mindy Mindy, and Hancock Prospecting's Roy Hill) are assumed to be conditioned to have no change potential on the Fortescue Marsh from disposal of excess dewatering water.
	Cumulative	None	None	Assumed to be conditioned to have no change potential on Fortescue Marsh from disposal of excess dewatering water.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Fortescue Marsh (Marsh Land System) PEC – Tier 2 Asset (cont'd)				
Full Conceptual Development	BHP Billiton Iron Ore only	High within a small portion of the southern fringe of the marsh related to Marillana. None for the remainder of the marsh.	None. Moderate to high change potential in local drainages and a portion of Weeli Wolli Creek due to reduced catchment at Marillana.	Excess dewatering water from Marillana, Mindy and Coondiner will require management to have no change potential on the Fortescue Marsh. AMD potential (pit lakes and overburden storage areas) is generally low but could be high if BHP Billiton Iron Ore targets deeper ore reserves at Mindy.
	Third-party only	None	None. Moderate to high change potential in local drainages and a portion of Weeli Wolli Creek due to reduced catchment at Brockman Resource's Marillana mining area.	Third-party operations (Brockman Resources' Marillana, FMG's Nyidinghu and Mindy Mindy, and Hancock Prospecting's Roy Hill) are assumed to be conditioned to have no change potential on the Fortescue Marsh from disposal of excess dewatering water.
	Cumulative	High within a small portion of the southern fringe of the marsh related to Marillana. None for the remainder of the marsh	Moderate. Cumulative reduction in catchment area greater than 5% from multiple mining areas.	Excess dewatering water from BHP Billiton Iron Ore and third-party operations will require management to have no change potential on the Fortescue Marsh. AMD potential is generally low but may increase if deeper ore reserves are targeted.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Freshwater Claypans of the Fortescue Valley (PEC – Tier 2 Asset)				
Existing Development	Cumulative	None	None	None
30% Conceptual Development	BHP Billiton Iron Ore only	None	None	None
	Third-party only	None	None	None
	Cumulative	None	None	None
Full Conceptual Development	BHP Billiton Iron Ore only	None	None. Low to moderate change potential confined to localised drainages in the vicinity of BHP Billiton Iron Ore's Roy Hill mining area.	Potential for surplus water from BHP Billiton Iron Ore's Roy Hill mining area. It is possible that a portion of excess dewatering water could be saline (in response to natural salinity).
	Third-party only	None	None	None
	Cumulative	n/a	n/a	Change potential is only related to BHP Billiton Iron Ore's operations.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Weeli Wolli Spring Community (PEC – Tier 2 Asset)				
Existing Development	Cumulative	None. Substantial drawdown in area of spring due to Rio Tinto's Hope Downs operation, but ecohydrological change at the spring is managed through irrigation.	None. Flow at Weeli Wolli Spring is being maintained through irrigation by Hope Down's operator.	Substantial discharge of excess dewatering water in Weeli Wolli Creek from Hope Downs, but water quality is fresh. Rio Tinto's Hope Downs operation is required to maintain the spring under Ministerial Conditions (i.e. 'The proponent shall ensure that supplementation of Weeli Wolli Spring protects dependent environmental values, as defined by the High Level Values Statement Weeli Wolli Springs & Creek November 2011, or subsequent revisions approved by the CEO of the Office of the EPA' as per Statement 893).
30% Conceptual Development	BHP Billiton Iron Ore only	Low. Small drawdown from Mining Area C towards spring; however, to be managed as a high change potential in recognition of spring sensitivity and analysis uncertainty.	Moderate. Reduction in catchment due to combined effect of Mining Area C (A and C Deposits) and Jinidi.	If both Mining Area C and Jinidi are considered, may be water negative (i.e., more water is required for operational use than is available from dewatering), requiring water supply (e.g. borefield); otherwise, slightly surplus.
	Third-party only	Moderate. Hope Downs closed by 2024, and residual drawdown dependent on closure strategy.	Low. Overburden storage areas rehabilitated and pit backfilled.	Rio Tinto's Hope Downs operation will be closed (planned closure in 2024). Change potential depends on Hope Downs closure strategy. The Hope Downs pit is planned to be backfilled, with residual drawdown predicted to recover by approximately 2050.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
	Cumulative	Moderate. Hope Downs closed by 2024, and residual drawdown dependent on closure strategy.	Moderate. Combined catchment reduction from Hope Downs, Mining Area C and Jinidi.	Change potential depends on the influence of operations at Hope Downs.
Full Conceptual Development	BHP Billiton Iron Ore only	Low to moderate. Encroaching drawdown from Mining Area C and Jinidi mining areas towards spring; however, to be managed as a high change potential in accordance with a precautionary approach.	High. Reduction in catchment due to combined effect of Mining Area C (A and C Deposits) and Jinidi mining areas.	For most of the period, operations are water negative (i.e., more water is required for operational use than is available from dewatering), which require water supply (e.g. borefield) with potential change potential on groundwater resource. There will be periods of dewatering surplus. Orebodies 13 and 16 in Jinidi mining area have moderate potential for AMD.
	Third-party only	High. Depends on closure outcomes from Hope Downs.	Low. Assuming Hope Downs overburden storage areas rehabilitated and pit backfilled.	Change potential at Weeli Wolli Spring will be dependent on the closure outcomes from Hope Downs.
	Cumulative	High. BHP Billiton Iron Ore effects to be managed as a high change potential; also depends on closure outcomes from Hope Downs.	High. Cumulative reduction in catchment from BHP Billiton and third-party operations.	Includes cumulative change potential from BHP Billiton Iron Ore operations and depends on closure outcomes from Hope Downs.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Karijini National Park (Tier 1 Asset)				
Existing Development	Cumulative	None	None. Minor (less than 5%) catchment reduction due to West Angelas mining area.	Rio Tinto's West Angelas mining area is licenced to discharge surplus water into local creek system. Existing borefield provides groundwater supply with potential change to groundwater resource.
30% Conceptual Development	BHP Billiton Iron Ore only	None	None	Water negative (i.e., more water is required for operational use than is available from dewatering) operations at Mudlark that may require groundwater supply, resulting in potential change to groundwater resource.
	Third-party only	None	Low (Turee Creek East Branch). Catchment reduction due to Rio Tinto's West Angelas mining area.	Rio Tinto's West Angelas mining area is licenced to discharge surplus water into local creek system. Borefield provides groundwater supply, with potential change to groundwater resource.
	Cumulative	None	Low. As above.	There is a combined effect of groundwater supply bores on the groundwater resource.

SCENARIO	OPERATIONS	ECOLOGICAL CHANGE POTENTIAL (PRIOR TO MITIGATION)		
		DRAWDOWN	SURFACE WATER AVAILABILITY	OTHER
Karijini National Park (Tier 1 Asset) (cont'd)				
Full Conceptual Development	BHP Billiton Iron Ore only	Low to moderate. Drawdown associated with Mudlark mine may extend to the national park; however, the likelihood is low owing to hydrogeological complexity, geological structure, topographic differences and separation distance. Further validation is necessary to confirm ecohydrological change potential.	Low. Catchment reduction due to Mudlark.	Mainly water negative operations that require potential groundwater supply, with potential change to groundwater resource. Occasional water surpluses, which require management.
	Third-party only	None	Low (Turee Creek East Branch). Catchment reduction due to Rio Tinto's West Angelas mining area.	West Angelas is closed.
	Cumulative	Low to moderate. As above.	Low. Catchment reduction due to Alligator South and West Angelas mining areas.	Aggregate change potential depends on BHP Billiton Iron Ore groundwater supply option and closure strategy.

- Ethel Gorge:
  - Environmental monitoring of groundwater levels and groundwater quality at Ethel Gorge; groundwater quality in Ophthalmia Dam; and the stygofauna assemblage at Ethel Gorge.
  - Maintenance of natural surface water flow into Ethel Gorge and further downstream within the Upper Fortescue River. Flows in Fortescue River are captured by Ophthalmia Dam during low flow events and provide recharge into the Ethel Gorge groundwater system.
  - Ophthalmia Dam and other existing MAR facilities provide for bulk and targeted replenishment of groundwater to minimise impacts in and near Ethel Gorge.
  - Surplus water may be returned to the groundwater system where practicable and appropriate. The most likely surplus water management approach will be MAR via discharge into Ophthalmia Dam. The use of MAR minimises the spatial extent of groundwater drawdown, thereby contributing to the preservation of stygofauna habitat.
  - Validation and refinement of the current ecohydrological conceptualisation for Ethel Gorge; including the contribution of groundwater to vegetation water use and level of dependence of the vegetation of groundwater.
- Fortescue Marsh:
  - Prior to mine development in the vicinity of Fortescue Marsh, review and consider the groundwater and surface water monitoring data collected by the existing mine operators (where and if available). Based on this review, target multi-level monitoring networks and data will be developed to address any knowledge gaps.
  - Surplus water management - Water availability to be matched with operational needs where possible, and opportunities actively sought for optimising water balances within mining areas and potentially between mining areas.
  - Management and mitigation of potential saline water ingress associated with orebody dewatering using options such as MAR.
  - Implement studies targeting any knowledge gaps (as required). Seek to collaborate with third parties where opportunities for mutual benefit are identified.
- Weeli Wolli Spring:
  - Environmental monitoring of recharge dynamics in the upper catchment, and throughflow effects relevant to Weeli Wolli Spring, stygofauna assemblage at Weeli Wolli Spring.
  - Appropriate interfacing with management program being implemented by third party operators, in consultation with Rio Tinto Iron Ore
  - Surplus water - Surplus water may be returned to the groundwater system where practicable and appropriate. The use of MAR may minimise the spatial extent of groundwater drawdown.
  - Surface water diversion - Augmentation of natural surface water flow into Weeli Wolli Spring via targeted drainages, if required.
  - Validating, amending and improving the current ecohydrological conceptualisation of Weeli Wolli Spring.
  - Quantitative analysis of surface water and groundwater interactions at Weeli Wolli Spring.

BHP Billiton Iron Ore considers that impacts to key ecohydrological receptors can be managed to an acceptable level through normal business management practices or though targeted management identified in the Water Management Toolkit (Figure 42). Impacts to key ecohydrological receptors as described above will be validated at the Derived Proposal stage as further detail is known about mine planning and design and baseline data, and management measures will be refined.

8.2.3 SUMMARY OF ASSESSMENT OUTCOMES

This section provides a summary of the assessment outcomes for Water environmental factors using the EPA's Environmental Guideline 9 (EPA 2015b) and presents BHP Billiton Iron Ore's view on whether the Strategic Proposal can be implemented consistent with EPA's objectives.

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact certain parts of the landscape through impacts to surface water as described above if appropriate mitigation is not implemented. The modelled outputs highlight the mitigation considerations for EHUs.

BHP Billiton Iron Ore considers that impacts to groundwater can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Water Management Toolkit. BHP Billiton Iron Ore has a proven track record of implementing water management measures to manage impacts to an acceptable level.

8.3 People

8.3.1 INTRODUCTION

The EPA theme People, as outlined in Environmental Assessment Guideline 8 (EPA 2015a), should include consideration of the following factors:

- Heritage;
- Amenity; and
- Human Health.

BHP Billiton Iron Ore manages and protects Aboriginal heritage in accordance with the WA *Aboriginal Heritage Act 1972* and the EPBC Act. Potential impacts to heritage sites associated with the Strategic Proposal will continue to be managed through BHP Billiton Iron Ore's internal heritage management processes. For completeness, information on BHP Billiton's heritage assessment and management process is provided in this PERSP, but EPA does not consider heritage to be a key factor for detailed consideration as it is managed via separate legislation. The engagement of Native Title Groups will continue to be guided by Heritage Protocols between the groups and BHP Billiton Iron Ore.

Human Health, at the strategic level, is addressed through the Air Quality, Amenity and Terrestrial Environmental Quality factors. Note, that for the purposes of impact assessment and management, the impacts to human health from noise, are dealt with under the Amenity assessment in this PERSP.

8.3.1.1 ENVIRONMENTAL FACTOR OBJECTIVES

The EPA applies environmental objectives to the assessment of proposals. BHP Billiton Iron Ore's contribution to achieving these factors for the theme People is summarised in Table 46.

Table 46: EPA and BHP Billiton Iron Ore environmental factor objectives for people

FACTOR	EPA OBJECTIVE (EPA 2015A)	BHP BILLITON IRON ORE OBJECTIVE[1]
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.	BHP Billiton Iron Ore shall mitigate risks to heritage from its activities to an acceptable level.
Amenity (includes Human Health)	To ensure that impacts to amenity are reduced as low as reasonably practicable	BHP Billiton Iron Ore shall mitigate risks to amenity from its activities to an acceptable level.

1. 'Acceptable level' is defined as per the EPA's significance framework in Environmental Assessment Guideline 9 (EPA 2015b); thus BHP Billiton Iron Ore considers an 'acceptable level' of impact to be a level of residual impact that meets the EPA's objectives for that environmental factor.

8.3.1.2 KEY LEGISLATION AND GUIDANCE

As discussed in Section 7.1, BHP Billiton Iron Ore has addressed applicable legislation, policy and guidance for each factor. These are detailed in Appendix 1, Table 1.3.

8.3.1.3 HERITAGE AND AMENITY MANAGEMENT TOOLKITS

Distinct from the other themes, management for the People theme occurs at the factor level, with separate management approaches for Heritage and Amenity.

Heritage

BHP Billiton Iron Ore is committed to meeting the requirements of the WA *Aboriginal Heritage Act 1972* and the EPBC Act to respect Aboriginal heritage and will continue to consult with Traditional Owners and other stakeholders regarding any proposed activities that have the potential to impact heritage values. Consultation with Native Title groups is described in Section 8.3.2.1.

BHP Billiton Iron Ore conducts its operations and manages its impacts to heritage in accordance with a standard set of heritage principles and its Heritage Management toolkit. The Heritage Management toolkit is illustrated in Figure 51.

Figure 51: BHP Billiton Iron Ore's Heritage Management toolkit

Amenity

BHP Billiton Iron Ore has a suite of mitigation measures that may be applied (Figure 52), in conjunction with adaptive management to achieve the outcome-based objectives for Amenity. The management measures presented are not exhaustive, and additional measures are likely to be developed over the life of BHP Billiton Iron Ore's operations and applied on a merit-based approach, in accordance with BHP Billiton Iron Ore's adaptive management.

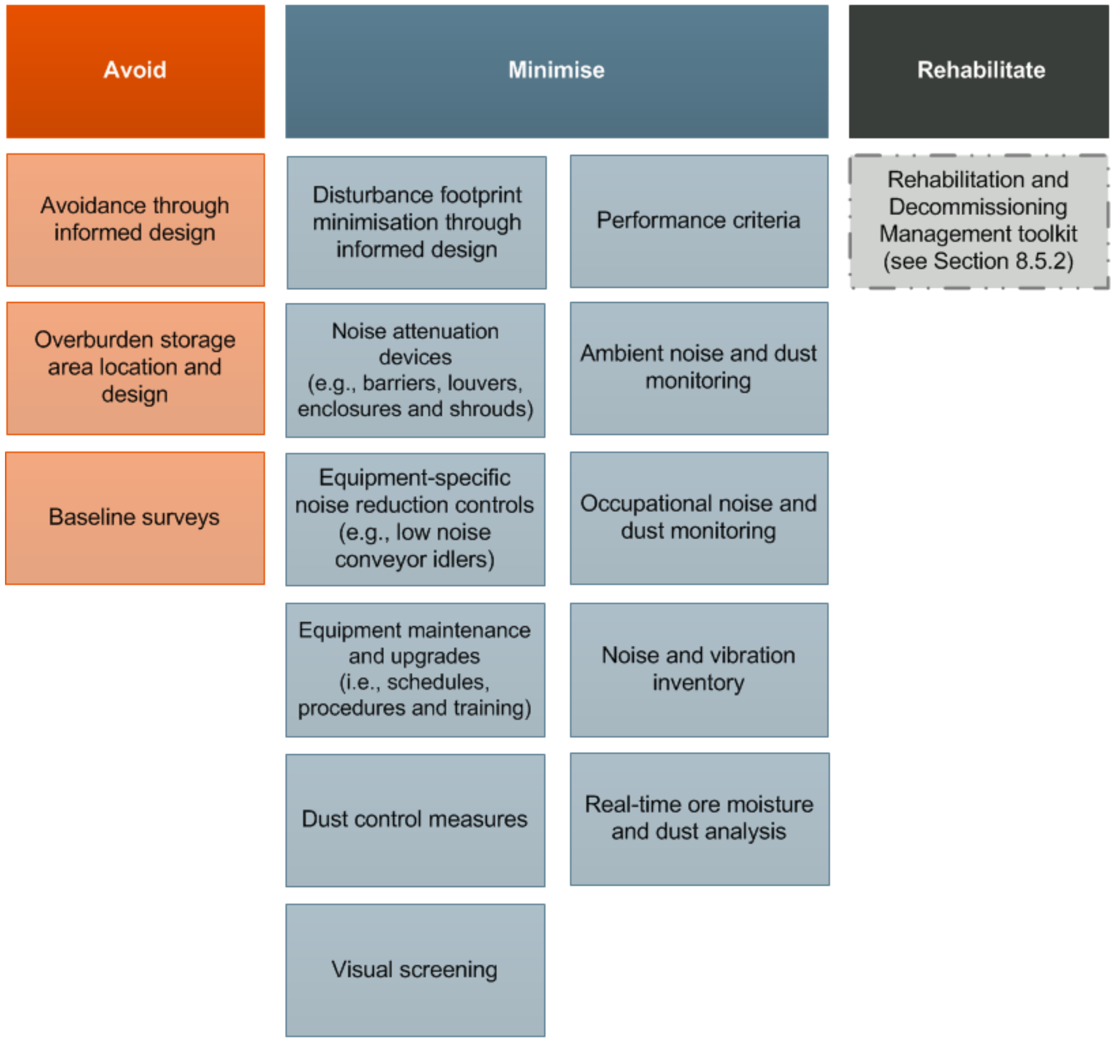


Figure 52: BHP Billiton Iron Ore's Amenity Management toolkit

8.3.2 ABORIGINAL HERITAGE ASSESSMENT

The Pilbara region is rich in Aboriginal heritage. Impacts to heritage sites, in terms of physical disturbance, are outside the scope of this assessment, and locations with heritage value are only assessed for potential impacts to visual amenity. Aboriginal heritage sites within the Project Definition Boundary are either ethnographic sites mainly associated with the Dreamtime and ceremonies or archaeological sites that are the remains of material culture. A number of these sites hold considerable visual amenity value (e.g. rock art and creeks or waterholes at water source sites).

8.3.2.1 EXISTING ENVIRONMENT

The Pilbara region hosts a prolific number of Aboriginal rock engravings, some of the most well-known being on the Burrup Peninsula (outside of the Project Definition Boundary). Similar engravings also occur within the Project Definition Boundary.

There are also numerous Aboriginal reserves within the Project Definition Boundary, such as Ethel Creek and the Weeli Wolli area. These Aboriginal reserves are Crown land set aside for public purposes, including hospitals, schools, conservation of plants and animals, national parks, recreation, and the use of Aboriginal people (DIA 2010).

Heritage and cultural sites are protected under the *Aboriginal Heritage Act 1972* and under the EPBC Act. Heritage surveys are ongoing and undertaken with participation by the relevant Native Title groups of the area. The engagement of Native Title groups is guided by Heritage Protocols between the groups and BHP Billiton Iron Ore. Native Title groups identified as key stakeholders within the Project Definition Boundary include the Kariyarra, Nyiyaparli, Palyku, Banjima, Ngarlawangga and Yinhawangka.

BHP Billiton Iron Ore has conducted large-scale archaeological and ethnographic surveys to identify places of cultural significance. Those surveys are ongoing and undertaken with participation by the relevant Traditional Owners of the area as described further in Section 8.3.2.4.

Consultation with the Native Title groups identified as key stakeholders is a critical component of the PERSP. Consultation has been undertaken with groups whose land is directly physically impacted by the Strategic Proposal and will also be undertaken with Aboriginal communities that are in proximity to the Strategic Proposal. Initial consultation on the Strategic Assessment addressed issues such as:

- What is the Strategic Assessment?
- Why are we doing it?
- What will it cover?
- How long will it take?
- What happens for future proposals.

A summary of this consultation to date is provided in Table 47.

Table 47: Summary of consultation with Aboriginal communities to date

CONSULTATION DATE	TOPICS COVERED
Nyiyaparli Group	
12 September 2012	General Strategic Assessment Overview (Presentation)
27 March 2013	Written Strategic Assessment update regarding progress to date – focus upon process Presentation on Water Management
12 September 2013	Written Strategic Assessment update re progress to date – focus upon process
13 March 2014	General Strategic Assessment Overview (Presentation)
18 September 2014	Written Strategic Assessment update re progress to date – focus upon process
30 January 2015	BHP Billiton Iron Ore Environment Team meeting with Nyiyaparli Regional closure and rehabilitation approach Current approvals General discussion on the Strategic Assessment – detailed presentation to be provided
1 April 2015	Site visit to a working mine to looked at closure and rehabilitation
14 April 2015	Introduced the proposal for an Independent Environmental Consultant to assist Traditional Owner groups with Strategic Assessment documents. Presented on Strategic Assessment with focus on what the Strategic Assessment is and potential flora and fauna and visual impacts. Discussed the above site visit. Presented on water management.
10 June 2015	Presentation to discuss current approvals and key findings. Confirmation of the engagement of the Independent Environmental Consultant. Update on the status of the Strategic Assessment
19 August 2015	Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners
12 October 2015	Presentation to discuss current approvals and key findings Update on the status of the Strategic Assessment

Consultation date	Topics covered
17 November 2015	Presentation by BHP Billiton Iron Ore on key environmental issues raised at the meeting on 19 August 2015. Separate discussions with the Independent Environmental Consultant on BHP Billiton Iron Ore's response.
Yinhawangka Group	
3 November 2014	Presentation on Water Management Presentation on the Strategic Assessment Talking with the Yinhawangka
27 August 2015	Presentation on Water Management Presentation on the Strategic Assessment Talking with the Yinhawangka Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners
21 October 2015	Presentation by BHP Billiton Iron Ore on key environmental issues raised at the meeting on 27 August 2015. Separate discussions with the Independent Environmental Consultant on BHP Billiton Iron Ore's response.
Ngarlawangga Group	
28 August 2015	Presentation on the Strategic Assessment Talking with the Ngarlawangga Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners
14 October 2015	Presentation by BHP Billiton Iron Ore on key environmental issues raised at the meeting on 28 August 2015. Separate discussions with the Independent Environmental Consultant on BHP Billiton Iron Ore's response.
10 December 2015	Presentation by BHP Billiton Iron Ore on its response to additional issues raised following the meeting on 14 October 2015. Separate discussions with the Independent Environmental Consultant on BHP Billiton Iron Ore's response.
Banjima Group	
2 December 2014	Presentation on Water Management Presentation on the Strategic Assessment Talking with the Banjima
23 September 2015	Presentation on the Strategic Assessment Talking with the Banjima Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners
Palyku Group	
16 November 2015	Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners.
Kariyarra Group	
12 November 2015	Presentation on the Strategic Assessment Presentation of key Strategic Assessment findings by an Independent Environmental Consultant as part of a process to identify key environmental issues of concern to Traditional Owners

8.3.2.2 POTENTIAL IMPACTS

BHP Billiton Iron Ore manages and protects Aboriginal heritage in compliance with the *Aboriginal Heritage Act 1972*. Potential impacts to heritage sites within the Project Definition Boundary will continue to be managed through BHP Billiton Iron Ore's internal heritage management processes. These processes are based on guidelines drafted by the Department of Aboriginal Affairs (DAA) and include measures to identify significant heritage sites during planning phases so as to avoid or minimise potential heritage impacts. If any heritage site cannot practically be avoided, BHP Billiton Iron Ore will consult with the relevant Aboriginal group and seek consent from the Minister under Section 18 of the *Aboriginal Heritage Act 1972* prior to undertaking any activities that may disturb the site. Some examples of potential impacts are summarised in Table 48.

Table 48: Potential impacts to Aboriginal heritage values from mining activities

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Activities or processes impacting heritage values (direct)	Mining operations may directly impact on heritage values through physical presence, which may involve clearing of vegetation, use or alteration of waterways, or impact to landscape. The extent of the potential impact depends on a number of factors, such as the activity and the use or significance of the heritage value.
Activities or processes impacting heritage values (indirect)	Mining operations may indirectly impact on heritage values through altered landuse, which may involve changes to water assets, increased public access, indirect impacts to vegetation or fauna values, or impact to landscape. The extent of the potential impact depends on a number of factors, such as the activity and the use or significance of the heritage value.

8.3.2.3 MITIGATION

To manage and protect Aboriginal heritage in compliance with the *Aboriginal Heritage Act 1972* and the EPBC Act, BHP Billiton Iron Ore utilises strict internal processes and procedures implemented by dedicated Heritage and GIS teams. Within surveyed areas, BHP Billiton Iron Ore documents the spatial location of each heritage place and, where practicable, adopts engineering solutions to avoid them. If any heritage site cannot practically be avoided, the Company seeks to consult with the relevant Native Title group and applies for approval from the Minister for Aboriginal Affairs under s. 18 of the *Aboriginal Heritage Act* 1972 before the site is disturbed.

BHP Billiton Iron Ore also has in place an internal procedure (i.e., PEAHR procedure) to internally manage conditions associated with all ground-disturbing activities and to ensure compliance with environmental, Aboriginal heritage, land tenure, legal commitments and regulatory requirements. The procedure provides a mechanism for the heritage specialists within the Heritage and GIS teams to provide technical and professional advice regarding cultural heritage management of sites, including protection requirements to ensure compliance with the *Aboriginal Heritage Act 1972*, EPBC Act and the relevant Native Title agreements.

BHP Billiton Iron Ore has entered into a claim-wide agreement with the Nyiyaparli Native Title group and the Banjima Native Title group; these agreements provide certainty about future tenure requirements beyond the existing lease and mining operations in the areas. As part of these agreements, BHP Billiton Iron Ore and the Native Title groups have agreed to specific cultural heritage commitments in relation to the management of heritage sites, including the recognition, mapping and capture of places of ethnographic importance (referred to as 'confidential areas'). BHP Billiton Iron Ore will seek to avoid impacts to these confidential areas under future Derived Proposals in line with its obligations under the agreement while the agreement is in force.

BHP Billiton Iron Ore is currently working towards similar agreements with the Kariyarra and Yinhawangka Native Title groups, and these will also include confidential areas. Additional discussions relating to the compilation of project agreements are currently being negotiated with numerous registered Native Title groups through the Pilbara.

BHP Billiton Iron Ore has developed the PEAHR procedure to internally manage and enforce conditions associated with all ground-disturbing activities and to ensure compliance with environmental, Aboriginal heritage, land tenure, legal commitments and regulatory requirements. The PEAHR procedure provides a mechanism for the heritage specialists within the Heritage and GIS teams to provide technical and professional advice regarding cultural heritage management of sites, including protection requirements, to ensure compliance with the *Aboriginal Heritage Act 1972*, EPBC Act and the relevant Native Title agreements.

Cultural heritage management at BHP Billiton Iron Ore is driven by the Sustainable Heritage Strategy. The strategy is underpinned by three elements – legal compliance, scientific research and legacy building – with three key objectives:

- comply with the *Aboriginal Heritage Act 1972,* EPBC Act, Heritage of Western Australia Act and other relevant legislation;
- guide the heritage approvals process by addressing key gaps in the knowledge base; and
- create a positive heritage legacy for future generations.

The strategy enables the effective facilitation of meaningful and effective partnerships that centre on common concerns and improve the ongoing management of the heritage landscape in the Pilbara.

BHP Billiton Iron Ore's heritage management protocols described above and ongoing consultation with Native Title groups will ensure that potential impacts to heritage sites within the Project Definition Boundary will continue to be managed to an acceptable level well into the future.

Specific examples of the mitigation toolkit being implemented in existing and proposed operations are provided in Table 49.

Table 49: Potential management approaches for Aboriginal heritage

Source of potential impact	BHP Billiton Iron Ore Management Approach Examples[1]
Direct or indirect impact to heritage values	• *Avoidance through informed design* by avoiding known sites and engaging with Native Title claimants to determine heritage values. • *Avoidance* or *minimisation through informed design* by demarcation of known sites of significance. • *Avoidance* through unauthorised clearing, access or activities through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • *Minimise* potential impact through consultation and via the development and application of a Cultural Materials Management Plan. • *Minimise* potential impact by monitoring cultural heritage sites • *Minimise* impact via the establishment of Native Title Agreements

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

8.3.2.4 SIGNIFICANCE OF IMPACTS

Cultural landscapes are an important element of the Aboriginal cultural heritage of the Pilbara. Aboriginal cultural values that represent past and present connection to country are not always represented physically in the landscape and can be imbued to a physical place or location through story, song, dance, language, kinship, custom, ceremony or ritual. Through these traditions, cultural heritage values may give shape, form and meaning to a particular landscape with or without an archaeological or physical component. This is termed a 'cultural landscape' and needs to be considered when assessing the significance of heritage places. The identification, mapping and management of cultural landscapes, while meeting regulatory requirements and taking into account stakeholder expectations and potential impacts to cultural significance, are key to BHP Billiton's heritage management approach.

BHP Billiton Iron Ore conducts archaeological and ethnographic surveys with the Native Title groups to identify any significant heritage sites situated within its areas of interest. Based on BHP Billiton Iron Ore's data, approximately 55% of the Full Conceptual Development Scenario area has been archaeologically surveyed, with all identified heritage sites (archaeological and ethnographic) managed by BHP Billiton Iron Ore's Heritage and GIS teams.

BHP Billiton Iron Ore will continue to engage with Native Title groups through targeted consultation and via administration of heritage agreements, and therefore any potential impacts to heritage values are considered to meet the EPA's factor objective through business-as-usual management standards, with a high level of certainty that acceptable outcomes will be achieved.

8.3.3 EUROPEAN HERITAGE ASSESSMENT)

8.3.3.1 EXISTING ENVIRONMENT

European settlement of the Pilbara began in the 1860s (van Vreeswyk et al. 2004). Pastoralism dominated the region for the next 100 years as European settlers arrived with livestock to establish sheep stations. Many of the European heritage sites in the Pilbara region relate to these historic pastoral stations, natural features (such as pools) and town sites.

For example, a search of the inHerit database (Heritage Council of WA 2015) indicates that there are over 90 heritage places in the Shire of East Pilbara. In the Newman area, many of these relate to stations, pools (Weeli Wolli Pool, Ophthalmia Dam), historic mining (Mt Whaleback mine) and sites within Newman (St Joseph's Catholic Church, Boomerang Grandstand).

According to the EPBC Act Protected Matters Search Tool, there are no World Heritage Places or National Heritage Places within the Project Definition Boundary.

8.3.3.2 POTENTIAL IMPACTS

In Western Australia, the *Heritage of Western Australia Act 1990* makes provision for the preservation of places of historic significance. Under the act, places identified as meeting the criteria outlined in section 47 are placed on the State Register of Heritage Places. Places of Commonwealth heritage significance are protected under Part 15 of the EPBC Act.

The risk of disturbance to man-made European heritage places is considered to be low. Many of these heritage places are located near or within town sites or stations. Although these sites are contained within the Project Definition Boundary, they are unlikely to be impacted by existing or new mines, which are typically located away from existing town sites.

POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Activities or processes impacting heritage values (direct)	Mining operations may directly impact on European heritage places through physical presence, which may involve clearing of vegetation, use or alteration of waterways, or impact to landscape. The extent of the potential impact depends on a number of factors, such as the activity and the use or significance of the heritage value.
Activities or processes impacting heritage values (indirect)	Mining operations may indirectly impact on European heritage places through altered landuse, which may involve changes to water assets, increased public access, indirect impacts to vegetation or fauna values, or impact to landscape. The extent of the potential impact depends on a number of factors, such as the activity and the use or significance of the heritage value. The potential indirect impacts to natural heritage places, such as water assets (for example Weeli Wolli Pool), are identified as key assets for their environmental values and are discussed elsewhere in the PERSP.

8.3.3.3 MITIGATION

The approach BHP Billiton Iron Ore takes when mitigating impacts to European heritage values is aligned with the approach to Aboriginal heritage, as detailed in Section 8.3.2.3 and summarised in Table 50.

Table 50: Potential management approaches for European heritage

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Direct impact to heritage values	• *Avoidance through informed design* by avoiding known sites. • *Avoidance* or *minimisation through informed design* by demarcation of registered sites of significance. • *Avoidance* through unauthorised clearing, access or activities through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • *Minimise* potential impact by monitoring heritage sites
Indirect impact to heritage values	• For Landscape Values refer to the Land and Biodiversity Management Toolkit (Section 8.1.1.3) • For water assets refer to the Water Management Toolkit (Section 8.2.1.3)

To manage and protect European heritage in compliance with the *Heritage of Western Australia Act 1990* and the EPBC Act, BHP Billiton Iron Ore utilises strict internal processes and procedures implemented by dedicated Heritage and GIS teams. Within surveyed areas, BHP Billiton Iron Ore documents the spatial location of each heritage place and, where practicable, adopts engineering solutions to avoid them. If any heritage site cannot practicably be avoided, the Company seeks to consult with the Heritage Council of WA and applies for approval from the Minister for Heritage under s. 64 of the *Heritage of Western Australia Act 1990* before the site is disturbed.

BHP Billiton Iron Ore's internal PEAHR procedure is used to manage conditions associated with all ground-disturbing activities and to ensure compliance with environmental, European heritage, land tenure, legal commitments and regulatory requirements. The procedure provides a mechanism for the heritage specialists within the Heritage and GIS teams to provide technical and professional advice regarding heritage management of sites, including protection requirements to ensure compliance with the Heritage of Western Australia Act.

8.3.3.4 SIGNIFICANCE OF IMPACTS

As impacts to European heritage values from potential implementation of the Strategic Proposal are not anticipated, the significance of impact to this factor is considered minimal. Where European heritage values align with natural features, these are managed as Tier 1 assets and dealt with accordingly (Section 8.1.2).

8.3.4 VISUAL AMENITY ASSESSMENT

Although not considered to be a key factor, Amenity was identified in the ESD (BHP Billiton Iron Ore 2013) as a potentially impacted environmental factor. Amenity is typically managed using BHP Billiton Iron Ore's standard management practices and approval requirements.

BHP Billiton Iron Ore has accumulated a wealth of data on social impacts through its experience operating in the Pilbara and has undertaken a number of studies to assess visual amenity. For the purpose of this assessment, Amenity is defined as both visual amenity and noise. Other factors, such as Air Quality and Atmospheric Gases and its impact on Amenity, are discussed in separate chapters.

8.3.4.1 EXISTING ENVIRONMENT

BHP Billiton Iron Ore commissioned 360 Environmental to conduct a landscape and visual risk assessment (LVRA) (Appendix 8). The study assessed the potential impact risks of the Strategic Proposal to visual amenity values and landscapes within the Project Definition Boundary.

The interaction between social and physical environments can often influence perceptions about visual amenity and landscape values present at particular locations. Known information on the social and physical settings was used to inform the selection of potentially valued locations.

Locations of value within the Project Definition Boundary were identified from several data sources. Due to the sensitivity and early phase of the Strategic Proposal, direct interaction with the public in identifying valued locations was limited. Where possible, locations with public interest were captured based on publicly available sources and were placed at a higher priority for surveying. Information sources that were used to identify potentially valued locations included:

- BHP Billiton Iron Ore's internal datasets – contain a list of regionally significant features, such as pools, hills, towns, streams, rock holes and gorges, as well as culturally significant locations;
- tourist maps – contain locations of recreational and regional interest likely to be accessed by tourists, generally with good levels of accessibility;
- four-wheel-drive forum and clubs – contain locations commonly accessed by the local four-wheel-driving communities with varying levels of accessibility;
- Newman Visitors Centre – several locally valued locations were identified through this source, as well as advice on accessibility and popularity; and
- other sources – these included public websites and social network sites that contain geotagged place marks of locations within the Project Definition Boundary. These locations were recorded by various members of the public, including tourists and local residents, and have varying levels of accessibility.

These information sources were reviewed to identify areas that may hold high visual amenity value. The following sections detail the types of locations targeted, as well as their inherent visual amenity values.

Water Features

A large number of water features in the form of creeks, rivers, pools and gorges exist in the Pilbara region. In a primarily semi-arid environment, water features are an important attraction for visitors (for example, the gorges, waterholes and creeks in the Karijini National Park area). As these are often located within gorges and areas of the landscape that are relatively recessed and sheltered, it is unlikely that their visual amenity will be directly impacted by the Strategic Proposal. However, in many cases, access to these locations requires travel over elevated areas or flat floodplains that may be visually impacted. As the access route will likely be accessed by a larger number of viewers, these were also included as potential target sites. Water features, in some cases, are sites of Aboriginal cultural significance and as such were given a higher survey priority.

Hills and Mountains

Accessible elevated positions within the landscape often have views over large areas of the landscape. Many of these hills and mountains are significant tourist attractions, often with lookouts boasting panoramic views at the summits (e.g. Mount Meharry, Mount Bruce, Mount Robinson and Mount Wildflower). These elevated areas were included as potential target viewpoints.

Towns and Homesteads

As towns represent centres of population with high numbers of potential viewers, locations within these were also included as potential target viewpoints.

Lookouts

There are several lookouts within the region, most often adjacent to major transportation corridors. As these locations are often in elevated positions overlooking visually appealing views, they often experience high visitor traffic and were therefore included as valued locations. Many lookouts are often demarcated with brown tourist signs, which may increase the likelihood of access by visitors.

Public Roads

As public roads are the most significant transportation corridor in the region, these locations are likely to receive a large amount of viewer traffic. Valued road locations included layovers, roadhouses and stopovers, as well as bridges. Several regionally and nationally significant roads exist within the Project Definition Boundary. Of largest significance (in terms of use) is the Great Northern Highway.

Heritage Sites

Common heritage locations within the Project Definition Boundary include Aboriginal sites, as well as abandoned mine sites, which are often significant tourist destinations and were therefore included as potential target sites. As Aboriginal heritage sites may involve restrictions on photography or entry, these sites are only discussed in terms of potential impacts and photographic plates are not included.

8.3.4.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara relevant to Amenity are listed in Table 51. A brief description of each potential impact is also provided.

Table 51: BHP Billiton Iron Ore's activities and their potential impacts associated with visual amenity.

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Permanent modification of landforms	The construction and operation of open-cut mines and the associated infrastructure can result in the permanent modification of landforms, for example, the removal of a ridgeline, the creation of mine voids, or the addition of an overburden storage area. These modifications may have adverse impacts on visual amenity where mining is not an existing land use.
Generation of dust	Generation of dust has potential to impact visual amenity by creating dust plumes that can be seen far away from where it is generated, if not mitigated appropriately.
Construction of roads and infrastructure	Improved transportation infrastructure and supporting services may facilitate visitation to areas where visual amenity is high. BHP Billiton Iron Ore considers this impact to be minor and has not considered it further within this document.

8.3.4.3 MITIGATION

BHP Billiton Iron Ore has a suite of mitigation measures that can be applied (Table 52), in conjunction with adaptive management, to achieve the outcome-based objectives for visual amenity. The management measures presented are not exhaustive, and additional measures are likely to be developed over the life of BHP Billiton Iron Ore's operations and applied on a merit-based approach, in accordance with BHP Billiton Iron Ore's adaptive management. An example of the application of the Amenity Management toolkit to visual amenity is summarised.

Table 52: Potential management approaches for visual amenity

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Permanent modification of landforms	• *Minimise* visual impact via visual screening methods, which may include screening structures, vegetation or engineering controls. Refer to Rehabilitation and Decommissioning Toolkit for further management measures.
Generation of dust	• Continue *consultation* activities to ensure dust impacting visual amenity is managed appropriately. Refer to the Air Management Toolkit for management measures.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

8.3.4.4 SIGNIFICANCE OF IMPACTS

The Project Definition Boundary was found to encompass a large variety of landscapes; however, two general landscape types were found to be most common immediately surrounding the proposed operational hubs: landscapes dominated by hills, ridges, plateaux and elevated areas and landscapes dominated by lower slopes and plains.

Landscapes dominated by hills, ridges, plateaux and elevated areas (corresponding to the Newman Land System) typically contain the largest diversity of locations with high visual amenity values (panoramic viewpoints, lookouts, gorges, rock pools and heritage sites). This is largely due to the large diversity of elements found at typical locations in the Newman Land System. The values often found at locations within this land system also tended to be synonymous with the visual character of the Pilbara (ancient, weathered, wide open spaces and contrasts between the soils, rocks, vegetation and sky).

Landscapes dominated by lower slopes and plains generally showed lower densities of locations with high visual amenity but were found to be a very common landscape type within the Project Definition Boundary (related to the Boolgeeda and Wannamunna land systems).

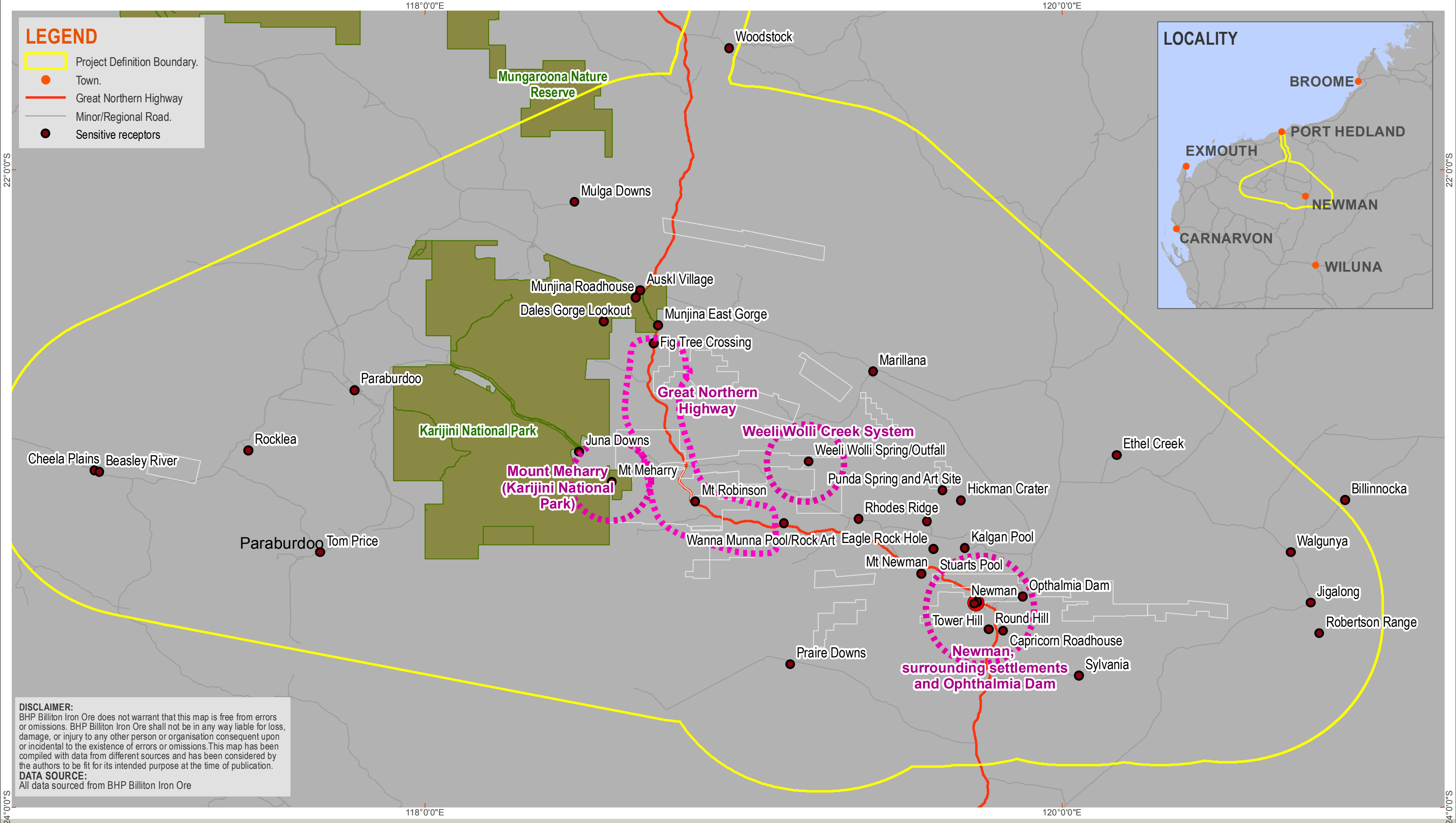
The LVRA has shown that impacts to regional landscape types are low, with maximum impact predicted to be approximately 2.6% for the Hamersley Plateaux. Impacts at local scales on individual land systems, however, may be considerably higher, peaking at 11% for the Wannamunna Land System (dominated by plains landscapes). Other land systems that were found to have high levels of cumulative impact (in order of decreasing potential impact levels) were the Jamindie (mulga-dominated hardpan plains), Pindering (mulga-dominated gravelly plains), Turee (stony alluvial plains) and Newman (hills, ridges and elevated areas) land systems. It should be noted that none of these land systems presents a unique view experience when other local landscapes within the Project Definition Boundary are considered. Impact levels to the Jamindie and Turee land systems were also found to stem primarily from third-party developments.

The assessment found that areas in the central area within the Project Definition Boundary (covering areas in proximity to South Flank, Mining Area C, Jinidi, Tandanya, Mudlark, and Gurinbiddy) are most at risk from impact resulting from the Strategic Proposal as it introduces mining as a relatively new land use (in publicly accessible areas). View experiences at many publicly accessible and high-value viewpoints (Great Northern Highway, Mount Meharry and Weeli Wolli Creek) may also be altered by the removal of elements contributing to visual amenity. The eastern area within the Project Definition Boundary (covering areas in proximity to Newman, Jimblebar, Caramulla, and Ophthalmia/Prairie Downs) may experience intensification in mining, an existing prevalent land use. The northern area within the Project Definition Boundary (covering areas in proximity to Yandi, Roy Hill, Marillana, Mindy, Coondiner, Ministers North, and Munjina/Upper Marillana) will likely generate a relatively lower level of impact due to the lower density of operations and the fewer number of publicly accessible sites. BHP Billiton Iron Ore's operation in the western area within the Project Definition Boundary (i.e. Rocklea) was found to have negligible levels of direct impact to surrounding sensitive receptors. These are discussed under several different priority areas below.

The LVRA (Appendix 8) found that impacts were generally most relevant to four 'priority areas' (locations with high densities of sensitive receptors):

- Newman, surrounding settlements and Ophthalmia Dam;
- Weeli Wolli Creek system;
- Great Northern Highway; and
- Mount Meharry (Karijini National Park).

The spatial distribution of these receptors is illustrated in Figure 53. Descriptions of the receptors within these priority areas (a total of 17 receptors were identified and assessed) with respect to their physical and socio-environmental characteristics are provided in the LVRA (Appendix 8).



Public Environmental Review
Strategic Proposal

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Figure 53 Sensitive receptors (visual amenity)

Newman, Surrounding Settlements and Ophthalmia Dam

The LVRA determined that Newman and its surrounds are a priority area for management due to its population being located in close proximity to potential impact. An important consideration when assessing impacts is that mining is already a prevalent land use surrounding Newman (Newman was built around the Mt Whaleback mine). The LVRA concluded that direct impacts to visual amenity in Newman are relatively minor, as the Strategic Proposal will only likely result in an intensification of an existing impact type. Figure 54 illustrates a 'before and after' photomontage of the various mining operations viewed from the top of Radio Tower Hill in Newman. As is evident, future impacts are relatively minor in comparison to existing impacts from current mining operations (the Orebody 25 operation is visible from this point). Note that indirect impacts from dust are not depicted as it is a subject of the separate air quality impact assessment (Appendix 9).

Ophthalmia Dam may experience intensification of existing view experiences, although impacts to its viewsheds are not as high as in other areas; and as is evident in Figure 55, changes to visual impacts are not anticipated to be significant.

Any impacts associated with mining operations in the vicinity may include alteration of current surface water and vegetation features, which are a key to the dam's visual amenity. Other impacts may include loss of public access as a result of access restrictions imposed by mining operations.

Weeli Wolli Creek System

The Weeli Wolli Creek system hosts a number of sites with high visual amenity values, including Weeli Wolli Spring, Hamersley Iron dewater discharge outlet and several swimming holes further downstream. The site is popular with tourists and locals as it contains pools that are filled with water year round (providing visual amenity and recreational values). Figure 56 presents a photomontage of the 30% Conceptual Development Scenario from the spring.

It is worth noting that impacts to the visual amenity of the creek are unlikely to stem from direct impacts (changes in viewsheds), due to the topography and small viewshed of the creek. No views of mining operations are expected from Weeli Wolli Creek.

Great Northern Highway

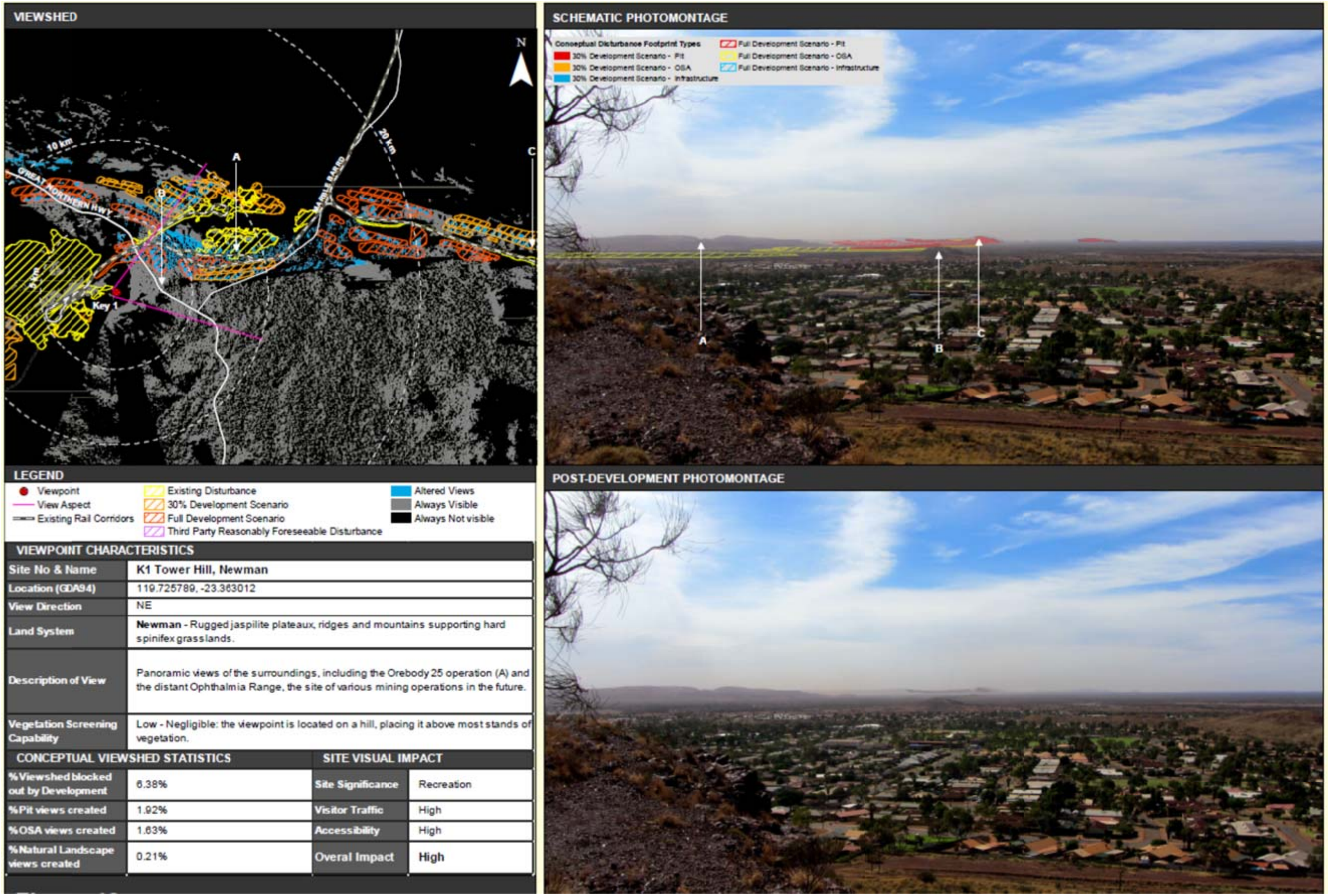
As the highway predominantly runs through areas of low elevation, the contribution of vegetation screening to visual amenity impacts was found to be significant. Figure 57 illustrates a photomontage of the 30% Conceptual Development Scenario from a location along the Great Northern Highway with little or sparse vegetation screening (note that, in this instance, the mining operation is relatively close to the highway).

Conversely, a denser stand of vegetation may significantly reduce impacts to visual amenity, as illustrated in Figure 58, which represents another photomontage of the 30% Conceptual Development Scenario.

Mount Meharry (Karijini National Park)

Karijini National Park contains a cluster of sites with high visual amenity values (due to the prevalence of 'rare' visual elements, such as gorges, rock pools and accessible elevated areas). However, the park is extremely large. The LVRA , based on a zone of visual influence estimate, only identified one site (Mount Meharry) as being potentially impacted by the Strategic Proposal. Mount Meharry, Western Australia's highest peak, is one of a small number of high-value locations within the southern section of the park. The park's most iconic sites (gorges and rock pools) are located in the north and are generally very resilient to amenity impacts due to their very small viewsheds (being situated within gorges or valleys).

Figure 59 illustrates a photomontage of the Full Conceptual Development Scenario from the summit of Mount Meharry.



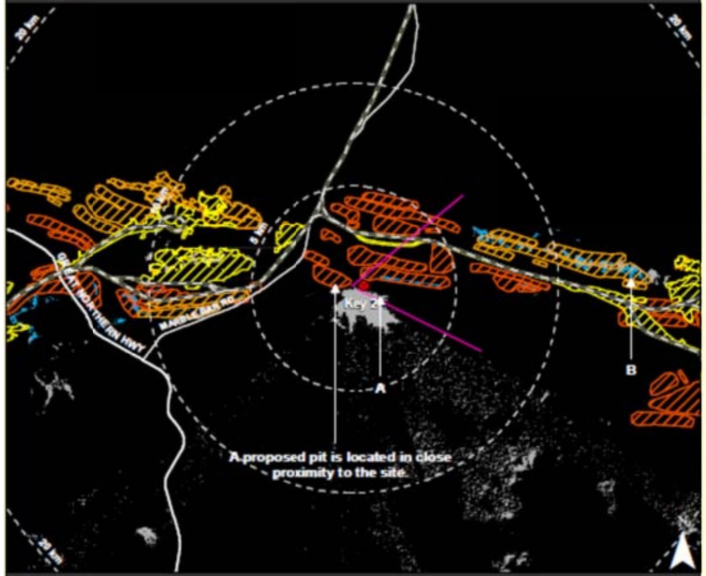
VIEWPOINT CHARACTERISTICS

Site No & Name	K1 Tower Hill, Newman
Location (GDA94)	119.725789, -23.363012
View Direction	NE
Land System	Newman - Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
Description of View	Panoramic views of the surroundings, including the Orebody 25 operation (A) and the distant Ophthalmia Range, the site of various mining operations in the future.
Vegetation Screening Capability	Low - Negligible: the viewpoint is located on a hill, placing it above most stands of vegetation.

CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	6.38%	Site Significance	Recreation
% Pit views created	1.92%	Visitor Traffic	High
% OSA views created	1.63%	Accessibility	High
% Natural Landscape views created	0.21%	Overal Impact	High

Figure 54: Existing view (top) and photomontage (bottom) of the eastern view from Radio Tower Hill in Newman

VIEWSHED



LEGEND

Viewpoint	Existing Disturbance	Altered Views
View Aspect	30% Development Scenario	Always Visible
Existing Rail Corridors	Full Development Scenario	Always not Visible
	Third Party Reasonably Foreseeable Disturbance	

VIEWPOINT CHARACTERISTICS

Site No & Name	K2 Ophthalmia Dam Picnic Area
Location (GDA94)	119.877737, -23.339803
View Direction	E
Land System	**Newman** - Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands. **McKay** - Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands with acacias and occasional eucalypts.
Description of View	The site is located along the northwestern banks of Ophthalmia Dam and is used as a picnic area. The site features, toilet and picnic facilities.
Vegetation Screening Capability	Moderate; vegetation in certain areas are capable of acting as effective screens.

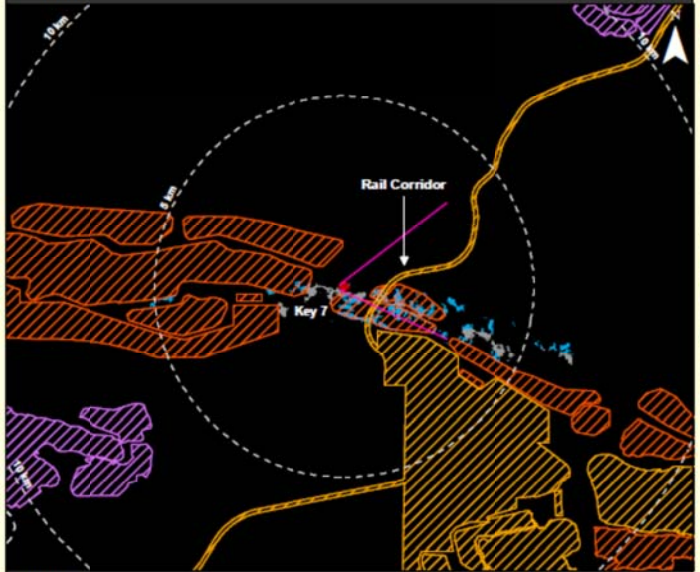
CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	9.79%	Site Significance	Recreation
% Pit views created	0.47%	Visitor Traffic	High
% OSA views created	5.22%	Accessibility	High
% Natural Landscape views created	0.13%	Overal Impact	**High**

SCHEMATIC PHOTOMONTAGE

POST-DEVELOPMENT PHOTOMONTAGE

Figure 55: Existing view (top) and photomontage (bottom) from Ophthalmia Dam picnic area

VIEWSHED



LEGEND

- Viewpoint
- View Aspect
- Existing Rail Corridor
- Existing Disturbance
- 30% Development Scenario
- Full Development Scenario
- Third Party Reasonably Foreseeable Disturbance
- Altered Views
- Always Visible
- Always Not visible

VIEWPOINT CHARACTERISTICS

Site No & Name	**K7 - Weeli Wolli Spring**
Location (GDA94)	119.20634, -22.91612
View Direction	E
Land System	**River** - Narrow, seasonally active flood plains and major river channels supporting moderately close, tall shrublands or woodlands of acacias and fringing communities of eucalypts sometimes with tussock grasses or spinifex.
Description of View	The viewpoint is located within the centre of Weeli Wolli Creek, a short distance from the spring. The site has high ecological, tourism, recreational, heritage and socio-cutural value.
Vegetation Screening Capability	High; Creekside vegetation provides screening for mine infrastructure and landforms, but not for dust.

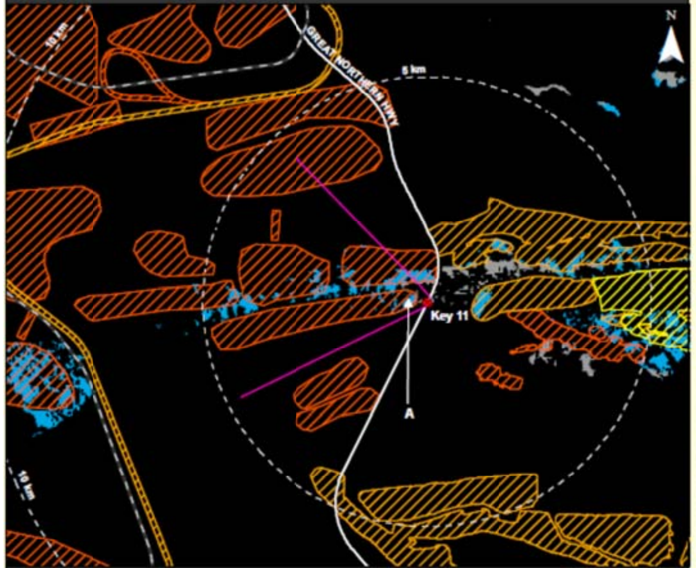
CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	36.10%	Site Significance	Socio-cultural, ecological, recreational
% Pit views created	9.22%	Visitor Traffic	Moderate
% OSA views created	8.40%	Accessibility	Moderate
% Natural Landscape views created	12.62%	Overal Impact	**High**

SCHEMATIC PHOTOMONTAGE

POST-DEVELOPMENT PHOTOMONTAGE

Figure 56: Existing view (top) and photomontage (bottom) of Weeli Wolli Spring

VIEWSHED



LEGEND

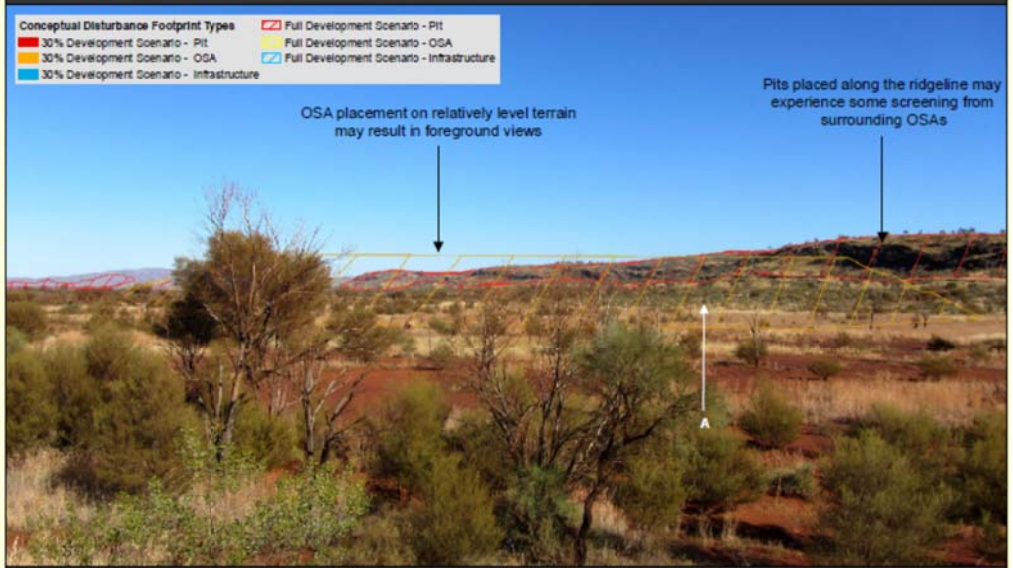
Viewpoint	Existing Disturbance	Altered Views
View Aspect	30% Development Scenario	Always Visible
Existing Rail Corridors	Full Development Scenario	Always Not visible
	Third Party Reasonably Foreseeable Disturbance	

VIEWPOINT CHARACTERISTICS

Site No & Name	K12 Great Northern Highway 11 (Iron Ore Ridge)
Location (GDA94)	118.81788, -22.93439
View Direction	W
Land System	**Wannamunna** - Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands and occasionally eucalypt woodlands. **Boolgeeda** - Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.
Description of View	This site is located alongside the Great Northern Highway and is considered significant as it runs in close proximity to two mining operations. Directly to the east is the eastern section of the Mining Area C mining operation which is to be developed in the 30% Development Scenario. The majority of the view shown in the plate will be altered in the Full Development Scenario.
Vegetation Screening Capability	Moderate-Low; as the majority of the pits in this area will be located on ridges, the screening potential of vegetation is limited.

CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	68.24%	Site Significance	Transport
% Pit views created	1.64%	Visitor Traffic	High
% OSA views created	11.76%	Accessibility	High
% Natural Landscape views created	3.59%	Overal Impact	**High**

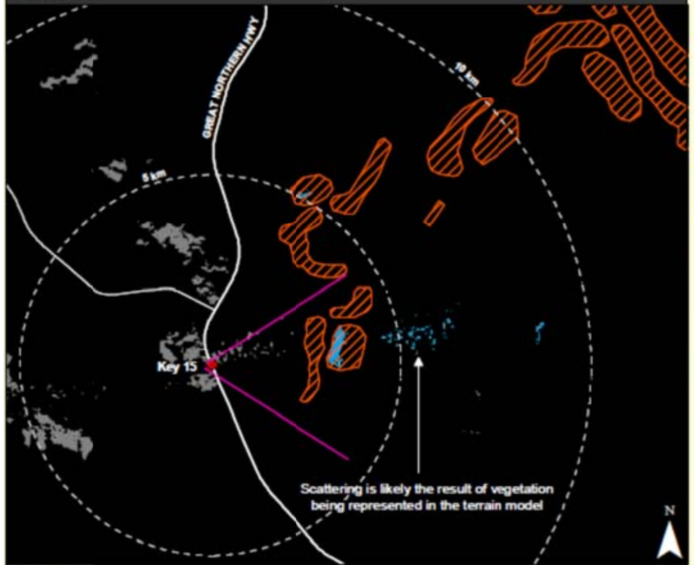
SCHEMATIC PHOTOMONTAGE



POST-DEVELOPMENT PHOTOMONTAGE

Figure 57: Existing view (top) and photomontage (bottom) of the Great Northern Highway Iron Ore Ridge

VIEWSHED



LEGEND

- Viewpoint
- View Aspect
- Existing Rail Corridor
- Existing Disturbance
- 30% Development Scenario
- Full Development Scenario
- Third Party Reasonably Foreseeable Disturbance
- Altered Views
- Always Visible
- Always Not visible

VIEWPOINT CHARACTERISTICS

Site No & Name	**K15 Great Northern Highway 15 (Marillana Bridge)**
Location (GDA94)	118.70065, -22.68164
View Direction	E
Land System	**Pindering** - Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.
Description of View	A lookout point overlooking Marillana Creek from the Great Northern Highway. The viewpoint is likely to be accessed after rains, while the creek is still flowing. Impacts to the Great Northern Highway in this section are likely to be moderate. This is partly due to the site being recessed in the landscape.
Vegetation Screening Capability	High; Proximity to the creek has resulted in an open eucalypt woodland with considerable screening potential.

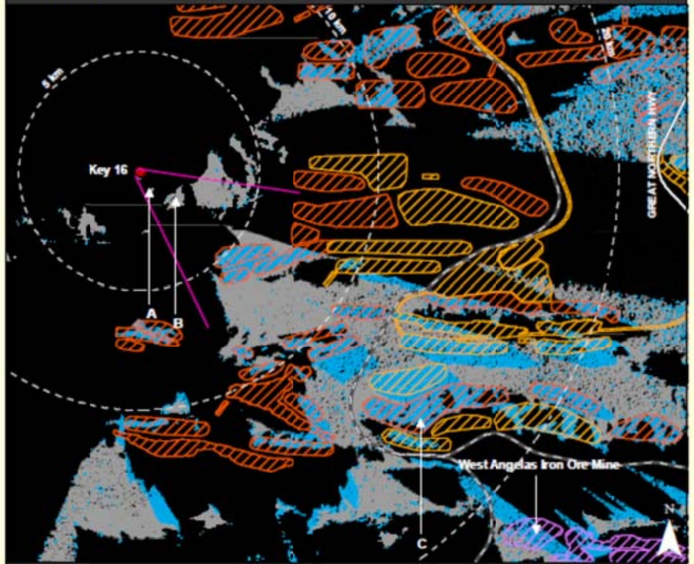
CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	7.50%	Site Significance	Major Transport Route
% Pit views created	0.34%	Visitor Traffic	High
% OSA views created	1.16%	Accessibility	High
% Natural Landscape views created	0.00%	Overal Impact	**Moderate**

SCHEMATIC PHOTOMONTAGE

POST-DEVELOPMENT PHOTOMONTAGE

Figure 58: Existing view (top) and photomontage (bottom) of the Great Northern Highway (Marillana Ridge)

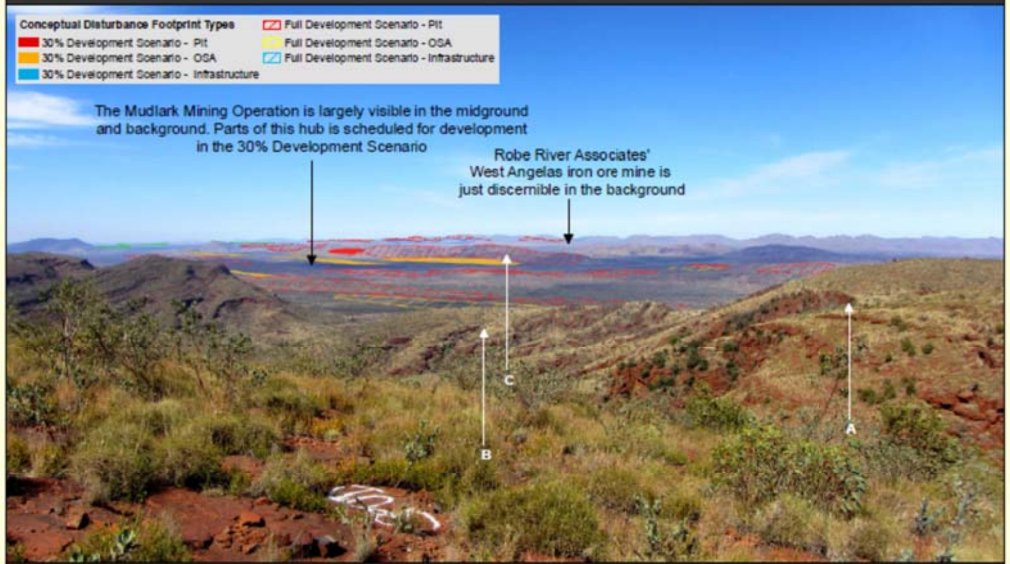
VIEWSHED



LEGEND

- Viewpoint
- View Aspect
- Existing Rail Corridors
- Existing Disturbance
- 30% Development Scenario
- Full Development Scenario
- Third Party Reasonably Foreseeable Disturbance
- Altered Views
- Always Visible
- Always Not visible

SCHEMATIC PHOTOMONTAGE



POST-DEVELOPMENT PHOTOMONTAGE

VIEWPOINT CHARACTERISTICS

Site No & Name	**K16 Mt Meharry (Southeast View)**
Location (GDA94)	118.587745, -22.98006
View Direction	SE
Land System	**Newman** - Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands. **Boolgeeda** - Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.
Description of View	The southeastern view from the summit of Mt Meharry, Western Australia's highest peak, which offers 360 degreee views of the surrounding landscape. It is estimated that close to 50% of the view from this site will be impacted by the development. Views to the east should largely be unaffected.
Vegetation Screening Capability	Low - negligible; the summit is relatively barren, with low shrubs.

CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	19.25%	Site Significance	Tourism, Socio-cultural
% Pit views created	2.13%	Visitor Traffic	Moderate
% OSA views created	7.16%	Accessibility	Moderate
% Natural Landscape views created	4.86%	Overal Impact	**High**

Figure 59: Existing view (top) and photomontage (bottom) of the south eastern view from Mount Meharry

From a quantitative perspective, the viewshed analyses used in the LVRA allow the classification of impacts. Figure 60 lists the impact categories for each priority area, as well as the minimum, maximum and average proportion of direct impact to the viewsheds of sites in these areas.

Table 53: Levels of potential direct impact at priority areas

Potential Impact Category	Minimum % of existing viewshed affected	Maximum % of existing viewshed affected	Average % of existing viewshed affected
Newman, Surrounding Settlements and Ophthalmia Dam - 4 receptor sites			
Views potentially blocked by the Strategic Proposal	6.38%	15%	7.51%
Potentially created views of overburden storage areas	1.63%	6.32%	3.97%
Potentially created views of pits	0.47%	2.2%	1.34%
Potentially created views of natural landscape	0.13%	3.45%	1.32%
Weeli Wolli Creek System - 2 receptor sites			
Views potentially blocked by the Strategic Proposal	27.8%	36.1%	31.95%
Potentially created views of overburden storage areas	6.98%	8.4%	7.69%
Potentially created views of pits	2.29%	9.22%	5.76%
Potentially created views of natural landscape	1.17%	12.62%	6.89%
Great Northern Highway - 9 receptor sites			
Views potentially blocked by the Strategic Proposal	7.5%	74.74%	34.81%
Potentially created views of overburden storage areas	1.16%	20.86%	8.07%
Potentially created views of pits	0.25%	5.31%	20.1%
Potentially created views of natural landscape	0%	12.15%	3.78%
Mount Meharry (Karijini National Park) - 2 receptor sites			
Views potentially blocked by the Strategic Proposal	19.25%	42.79%	31.02%
Potentially created views of overburden storage areas	7.16%	11.32%	9.24%
Potentially created views of pits	2.13%	4.69%	3.41%
Potentially created views of natural landscape	4.86%	6.52%	5.69%

Note that direct impacts for the Weeli Wolli Creek system are overestimated. As the assessment made use of a regional-scale terrain model, the fineness of the creek meant that the model may have smoothed out the creek slightly, resulting in a slightly flatter profile than is actually present. This results in a viewshed that is larger than what is present on site.

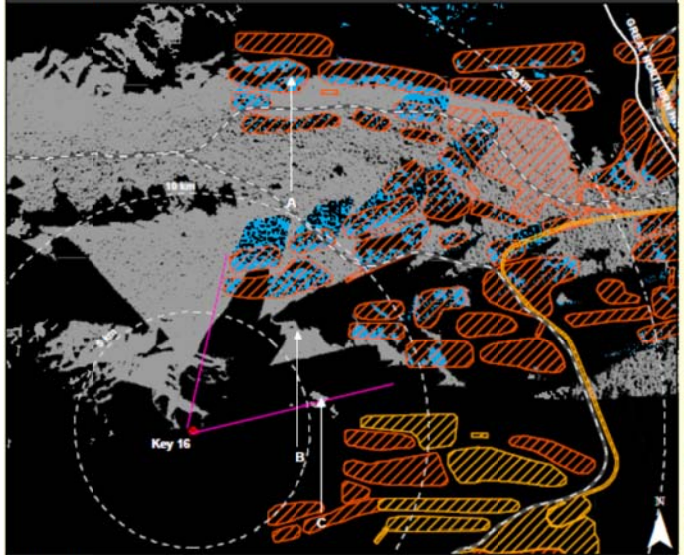
Cumulative impacts to visual amenity were assessed using photomontage analysis in the LVRA. The majority of key viewpoints identified in the LVRA are located at a distance at which cumulative impacts are expected to be minimal, except at Mount Meharry and Weeli Wolli Creek.

Mount Meharry was found to have the potential for exacerbated cumulative impact levels primarily because its elevation results in a large viewshed. The assessment also noted that cumulative visual amenity impacts may be exacerbated from Mount Meharry where the potential removal of a ridgeline in the Full Conceptual Development Scenario exposes views of Robe River's West Angelas mining operation. The study also noted, however, that the West Angelas mine is expected to have reached the end of its life when the Mudlark mining operation is developed (30% Conceptual Development Scenario). The viewshed analysis depicting this is illustrated in Figure 60. In addition, cumulative dust impacts may decrease visual amenity from Mount Meharry; however, dust models predict that ambient dust concentrations may be higher at this site under both the 30% Conceptual Development Scenario and Full Conceptual Development Scenario by a small margin only (Appendix 9). Implementation of the mitigation hierarchy (avoid, minimise, rehabilitate and offset) throughout the closure process and increased vegetative cover following rehabilitation will improve visual amenity over time.

Analysis in the LVRA shows that visual amenity at sites along Weeli Wolli Creek are unlikely to be directly impacted; this is because no views of mining operations are expected. The creek may experience cumulative impacts due to a number of third-party developments (the proposed Yandicoogina expansion projects) in its immediate surrounds. Indirect cumulative impacts to Amenity may result from alterations to the creek's surface water flow patterns or from direct interference from mining activities.

Other key viewpoints are not expected to be significantly impacted by the Strategic Proposal due to their distance from disturbance, and thus such impacts are considered acceptable.

VIEWSHED



LEGEND

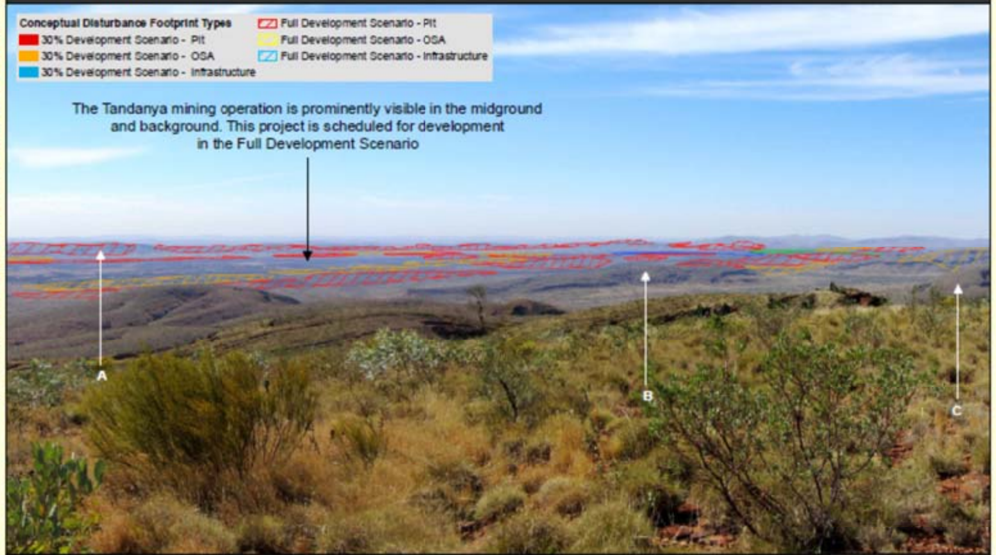
- Viewpoint
- View Aspect
- Existing Rail Corridors
- Existing Disturbance
- 30% Development Scenario
- Full Development Scenario
- Third Party Reasonably Foreseeable Disturbance
- Altered Views
- Always Visible
- Always Not visible

VIEWPOINT CHARACTERISTICS

Site No & Name	**K16 Mt Meharry (Northeast View)**
Location (GDA94)	118.587745, -22.98006
View Direction	NE
Land System	**Newman** - Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands. **Boolgeeda** - Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.
Description of View	The northeastern view from the summit of Mt Meharry, Western Australia's highest peak, which offers 360 degreee views of the surrounding landscape. It is estimated that close to 50% of the view from this site will be impacted by the development. Views to the west should largely be unaffected.
Vegetation Screening Capability	Low - negligible; the summit is relatively barren, with low shrubs.

CONCEPTUAL VIEWSHED STATISTICS		SITE VISUAL IMPACT	
% Viewshed blocked out by Development	42.79%	Site Significance	Tourism, Socio-cultural
% Pit views created	4.69%	Visitor Traffic	Moderate
% OSA views created	11.32%	Accessibility	Moderate
% Natural Landscape views created	6.52%	Overal Impact	**High**

SCHEMATIC PHOTOMONTAGE



POST-DEVELOPMENT PHOTOMONTAGE

Figure 60: A viewshed from the south eastern edge of Mt Meharry demonstrating potential cumulative impacts from ridgeline removal

8.3.5 NOISE ASSESSMENT

The cumulative noise impact assessment for the Strategic Proposal focused on human noise-sensitive receptors spread across the area within the Project Definition Boundary. This section provides a summary of the detailed noise assessment described in Appendix 10. A number of existing anthropogenic noise sources from both BHP Billiton Iron Ore and third-party operations will contribute to the baseline levels disproportionally across the region. The potential impact of these operations is directly related to the type and scale of the operation, their proximity to sensitive receptors and the management actions implemented. For the purpose of this assessment, noise emissions were considered from BHP Billiton Iron Ore's mining and rail operations and from third-party mining operations. Baseline noise levels were determined from comprehensive noise models rather than measurements.

The objectives of the cumulative environmental noise impact assessment were to:

- identify noise-sensitive receptors within the Project Definition Boundary;
- quantify the cumulative noise impacts from existing development within the Project Definition Boundary;
- quantify the cumulative noise impacts from the 30% Conceptual Development Scenario;
- quantify the cumulative noise impacts from the Full Conceptual Development Scenario; and
- assess compliance with the applicable noise legislation for operations and transport noise at noise-sensitive receptors.

8.3.5.1 EXISTING ENVIRONMENT

A regional-scale noise model comprising BHP Billiton Iron Ore's mining operations and third-party projects was developed on the basis of actual production rates for the existing mines and estimated production rates for proposed operations. The noise model relies on noise inputs established by correlating the noise emission levels and tonnes mined per annum. The model outputs (noise contours and noise levels at sensitive receptor locations) were used to determine where legislated noise criteria may be exceeded at sensitive receptors. Where this was predicted, the most significant contributor was identified. Particular attention was given to areas where noise impacts may occur as a by-product of operations managed by several proponents.

As with the other technical assessments, three development scenarios have been considered and, in this case, modelled. Existing Development (baseline), the 30% Conceptual Development Scenario and the Full Conceptual Development Scenario have been identified for the purposes of emission estimation and inclusion in the noise model. It is highly unlikely that the Full Conceptual Development Scenario will occur in reality; however, it has been presented to provide a conservative worst-case prediction for cumulative impact assessment purposes. For each of the three modelled scenarios, noise models have been developed to reflect the following:

- BHP Billiton Iron Ore's mining operations;
- BHP Billiton Iron Ore's rail operations;
- mining operations by third-party proponents; and
- cumulative impacts from BHP Billiton Iron Ore's and third-party mining operations.

Production rates for the existing BHP Billiton Iron Ore operations are based on actual tonnages, with rates for future operations (i.e. 30% and Full Conceptual Development Scenarios) assumed to be 45 Mtpa.

Third-party projects considered in the assessment are those that have been approved or are underway as at June 2012. For the noise assessment, third-party iron ore projects within 50 km of a BHP Billiton Iron Ore existing or proposed operation were included in the assessment. The exception is Roy Hill Iron Ore Mine (Roy Hill Iron Ore Holdings Pty Ltd), which is outside the Project Definition Boundary but has been included because of its close proximity to the Fortescue Marsh. Production rates for third-party iron ore projects are assumed to be at production capacity (either approved or proposed) for each scenario. Actual production rates for the baseline could not be used as this information is not publicly available for all proponents that have been identified as currently active. Where production capacity for third-party iron ore projects was not publicly available, a production capacity of 45 Mtpa was used, consistent with the assumption for future BHP Billiton Iron Ore operations.

For the purposes of cumulative noise impact assessment, it is assumed that each mining operation will generate noise from:

- haul roads;
- loading and unloading (ore and waste);
- blasting;
- crushing (including primary and secondary crushing) and screening;
- stacking or reclaiming;
- rail load-out; and
- miscellaneous transfers.

Given that some mining operations will not include all activities at each location (i.e. some mines may be considered satellite orebodies and may not include secondary crushing), this is considered to be a conservative approach as it is likely to overstate rather than underestimate regional noise emissions.

Generic noise emission levels were derived from detailed desktop noise studies previously conducted for BHP Billiton Iron Ore for Mining Area C and Orebody 24. Sound emissions for various production rates were derived from these reference studies. The derived noise emission levels assume standard noise control measures will be used as employed at Mining Area C and Orebody 24.

Rail noise impacts are directly related to the amount of iron ore extracted by BHP Billiton Iron Ore. The production rate of each operation determines the number of trains required to transport the iron ore to Port Hedland. This in effect determines the number of train pass-by events and thus the amount of noise exposure that a sensitive receptor located close to the railway line will be exposed to.

The rail noise model subdivided the rail footprint into separate rail sections for each mining operation. Each section was then associated with a rail loop at the facility yard and a ‘straight’ track segment via which the iron ore is transported to the main Port Hedland line. Each component was allocated a track speed and a number of train pass-by events derived from the throughput of a given mining operation. This information was then used to calculate the noise emission for each track component and the main line to Port Hedland.

The noise assessment considered the following sensitive receptor locations in the model:

- Aboriginal camp site – Wirrilimarra Community Area;
- Aboriginal community – Jigalong, Robertson Range, Walgunya (note that no one permanently resides at Robertson Range or Walgunya at present);
- recreation camp site – Karijini Eco Retreat;
- homestead – Cheela Plains, Ethel Creek, Juna Downs, Marillana, Mulga Downs, Prairie Downs, Rocklea, Sylvania;
- lookout – Fig Tree Crossing Lookout, Mount Bruce Lookout, Mount Meharry, Mount Newman, Munjina East Gorge, Tower Hill;
- recreation site – Dales Camp Area , Eagle Rock Hole, Hickman Crater, Kalgan Pool, Ophthalmia Dam, Round Hill, Stuarts Pool, and Weeli Wolli Spring and Outfall;
- rest stop – Beasley River, Mount Robinson;
- roadhouse – Auski Village, Capricorn, Munjina;
- town centre – Newman, Tom Price; and

- town site – Rhodes Ridge.

8.3.5.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara relevant to Noise are listed in Table 54. A brief description of each potential impact is also provided.

Table 54: BHP Billiton Iron Ore's activities and their potential impacts associated with noise.

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Pre-clearing works and construction of infrastructure	Pre-clearing works and construction of infrastructure can result in noise being generated, usually it is not long term. This can impact sensitive receptors that are nearby, but are usually limited to daytime activities.
Mining activities during operations	Mining operations can create noise through use of mobile and fixed plan equipment, or by changing landforms that may act as physical barriers to noise, which can impact sensitive receptors if in close proximity to mining operations and noise is not mitigated appropriately. Mining operations typically occur 24 hours a day, 7 days a week.
Transportation of ore via rail	Transportation of ore via rail can create noise, which can impact sensitive receptors if in close proximity to rail lines if not mitigated appropriately. Rail transportation typically occurs 24 hours a day, 7 days a week.

8.3.5.3 MITIGATION

BHP Billiton Iron Ore has a suite of onsite mitigation measures (a 'mitigation toolkit') that can be applied to achieve the outcome-based objectives for noise amenity (Figure 52). The management measures presented are not exhaustive; additional measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied on a merit-based approach, in accordance with BHP Billiton Iron Ore's adaptive management approach. An example of the application of the Amenity Toolkit for noise is provided in Table 55.

Table 55: Potential management approaches for noise amenity

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Pre-clearing works and construction of infrastructure	• *Avoidance* or *minimisation through informed design* by locating mining and mining-related activities away from sensitive receptor locations.
Mining activities during operations	• *Avoidance* or *minimisation through informed design* by locating mining and mining-related activities away from sensitive receptor locations. • *Minimise* noise by the *use of noise-attenuating devices*, such as barriers and enclosures. • *Minimise* noise by the *use of equipment-specific noise reduction controls* (e.g. Case Study 9). • *Minimise* noise exceedances by *monitoring ambient and occupational noise* against *performance criteria* and adaptively managing any exceedances.
Transportation of ore via rail	• *Avoidance* or *minimisation through informed design* by locating mining and mining-related activities away from sensitive receptor locations. • *Minimise* noise exceedances by *monitoring ambient and occupational noise* against *performance criteria* and adaptively managing any exceedances.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

The application of BHP Billiton Iron Ore's approach to managing noise is demonstrated in Case Study 9.

Case Study 9: Yelloroll noise reduction

Although noise is not a significant issue for the majority of BHP Billiton Iron Ore's operations due to their separation distance from sensitive receptors, it is still an operational factor that is assessed and managed when required across the business. In 2009, BHP Billiton Iron Ore's Dust and Noise Working Group identified various initiatives to decrease the environmental impact of noise from BHP Billiton Iron Ore operations on the town of Port Hedland and surrounding communities. The working group recognised that the cumulative effect of approximately 50 km of conveyor idlers was one of the more significant contributors to the received noise levels in the town of Port Hedland. As a result, one of the initiatives identified by the group was to trial a range of ultra-low-noise idlers (ULNIs) on a conveyor at the Port Hedland port facility. The Yelloroll idler (shown in the photograph) was one of the ULNIs investigated. The ULNI study was a long-term assessment of seven different rollers that started in 2009 and finished in 2012. This study enabled BHP Billiton Iron Ore to assess the noise reduction achieved, as well as the reliability and maintainability of the low-noise idlers, and to determine how the noise levels from the idlers degraded over time.

The outcomes of the study found that the Yelloroll ULNI offered the largest noise reduction of up to 8 dB when compared to standard steel idlers. It was also found that this idler had the following additional maintenance and reliability benefits:

- 41% lighter than the standard steel rollers making them easier for maintainers to handle;
- design eliminates the potential for a failed idler to cut the conveyor belt;
- flush end cap reduces the possibility of the rotating components jamming; and
- corrosion free.

The introduction of the Yelloroll ULNI at the Port Hedland operations has enabled throughput to increase, while noise levels have been maintained and in some instances reduced. The Yelloroll ULNI is the new standard across the business because of the noise-mitigation (and sustainable operational) benefits.

Source: BHP Billiton Iron Ore.
Yelloroll idler

8.3.5.4 SIGNIFICANCE OF IMPACTS

The statutory and policy instruments relevant to the EPA's assessment of noise impacts on Amenity or Human Health factors in Western Australia are the EP Act, the Environmental Protection (Noise) Regulations 1997, and the State Planning Policy 5.4, Road and Rail Transport Noise and Freight Considerations in Land Use Planning (SPP 5.4). Separate noise assessment criteria apply to industrial noise (e.g. mining operations) and transportation noise (e.g. rail operations).

The Environmental Protection (Noise) Regulations 1997 operate as a prescribed standard for noise emissions under the EP Act. Regulation 7 requires that noise emitted from any premise must comply with assigned noise levels when received at any other premises and be free of the intrusive characteristics of tonality, modulation and impulsiveness. Further, the noise emissions must not 'significantly contribute' to exceeding the assigned levels. Mining operations fall within the category of complex industrial noise sources that have a high potential to adversely affect the environment. This is mainly due to a large number of noisy fixed plant and mobile equipment scattered over a relatively large area. Furthermore, mining operations are typically continuous operations, which may lead to significant behavioural disturbances of the exposed population even when adverse health effects are not likely. In addition, noise from mining operations is often tonal or impulsive in nature and, thus, can cause nuisance and be difficult to mitigate.

The assigned levels are specified under Regulation 8 according to the type of premises receiving the noise. The noise regulations define all premises, other than commercial or industrial premises, as 'noise-sensitive premises'. Table 56 shows the noise level (LA_{10}) limits applicable for noise emissions from mining operations. The limits are conservative in nature and are representative of the worst-case night-time conditions. The less stringent noise level limit attributed to recreational sites, lookouts, rest stops and cultural sites has been determined based on the assumption that these areas will be occupied intermittently and for short periods of time.

The Environmental Protection (Noise) Regulations 1997 do not apply to noise emissions from motor vehicles or trains operating on road or railway infrastructure. SPP 5.4 is a statutory planning policy instrument prepared by the Western Australian Planning Commission and is given effect through the various planning stages and processes in Western Australia. SPP 5.4 aims 'to promote a system in which sustainable land use and transport are mutually compatible' by addressing noise impacts from major transport corridors on nearby noise-sensitive land uses. SPP 5.4 provides targets and limits, as received outdoors at a noise-sensitive land use, for day and night noise emissions from road and rail transport.

Table 57 provides the more stringent night-time criteria that have been applied to this assessment to ensure a conservative approach. Although the noise criteria are unlikely to be applicable to all rail expansions[8] for the Strategic Proposal, BHP Billiton Iron Ore will assess its predicted rail noise emissions against the SPP 5.4 criteria in all instances as a conservative approach.

Table 56: Noise limits applied to the mining operation assessment

NOISE-SENSITIVE RECEPTOR	TIME OF DAY	ASSIGNED NOISE LEVEL
Residential dwellings	2200 to 0700 Mon. to Sat. 2200 to 0900 Sun. and Public Holiday	35 dB(A)
Recreational sites, lookouts, rest stops and cultural sites	2200 to 0700 Mon. to Sat. 2200 to 0900 Sun. and Public Holiday	60 dB(A)

Table 57: Noise limits applied to the rail operation assessment

TIME OF DAY	NOISE TARGET	NOISE LIMIT
Night (10 pm to 6 am)	50 dB(A)	55 dB(A)

Table 58 presents the predicted noise levels at sensitive receptor locations due to mining operations for all three considered scenarios (i.e. Existing Development and 30% Conceptual and Full Conceptual Development Scenarios). The table contains only those sensitive receptor locations where the noise levels were predicted to either exceed or be within 5 dB of the assigned noise level, and the highest received levels are shaded grey. Detailed results for all sensitive receptors are presented in Table 59 and contained in Appendix 10.

[8] For example, an increase in tonnage along a BHP Billiton Iron Ore–operated railway does not trigger the policy; however, a new rail segment does trigger the policy.

Table 58: Predicted noise levels resulting from mining operations

Site Name and Description	Existing Development Scenario (predicted noise level in dB(A))			30% Conceptual Development Scenario (predicted noise level in dB(A))			Full Conceptual Development Scenario (predicted noise level in dB(A))			Assigned Noise Level dB(A)
	BHP Billiton Iron Ore	Third-party	Cumulative	BHP Billiton Iron Ore	Third-party	Cumulative	BHP Billiton Iron Ore	Third-party	Cumulative	
Marillana Homestead	18.2	23.5	24.6	27.6	**40.9**	**41.1**	29.2	**40.9**	**41.2**	35
Newman Town Centre	30.4	14.2	30.5	**38.2**	18.8	**38.2**	**38.3**	18.8	**38.3**	35
Capricorn Roadhouse	26.8	9.7	26.9	30.4	15.3	30.5	30.5	15.3	30.6	35
Tom Price Town centre	-2.3*	33.8	33.8	-0.6*	33.8	33.8	10.0	33.8	33.8	35
Rhodes Ridge Town Site	21.8	21.2	24.5	25.0	30.0	31.2	27.6	30.0	32.0	35

*Negative numbers arise due to the calculation method and results in a predicted or measured level that is negative being smaller than the reference pressure (SPL= 20*log10((Measured or Predicted Pressure)/(Pressure Reference) (Pressure Reference = 20microPa). When Measured or Predicted Pressure< Pressure Reference the value is less than 0.

Table 59: Sensitive receptor locations used for the PERSP noise impact assessment

Receptor ID-	Site Name	Site Location (Easting z50)	Site Location (Northing z50)
PR01	Juna Downs Homestead	652321	7468375
PR02	Ethel Creek Homestead	825483	7464467
PR03	Marillana Homestead	747479	7495073
PR04	Mulga Downs Homestead	651662	7555182
PR05	Prairie Downs Homestead	719290	7393667
PR06	Sylvania Homestead	811750	7388078
PR07	Newman town centre	779758	7414360
PR08	Tom Price town centre	568645	7434001
PR09	Munjina Roadhouse	671172	7521766

Receptor ID-	Site Name	Site Location (Easting z50)	Site Location (Northing z50)
PR10	Auski Village	672582	7524176
PR11	Rocklea Homestead	545802	7469519
PR12	Rhodes Ridge town site	742012	7443807
PR13	Capricorn Roadhouse	787812	7404112
PR14	Cheela Plains	496225	7462730
PR15	Beasley River rest stop	497719	7462195
PR16	Mount Robinson rest stop	689526	7450659
PR17	Munjina East Gorge	678283	7512021
PR18	Fig Tree Crossing Lookout	676697	7505825
PR19	Mount Meharry	662753	7457807
PR20	Mount Newman	761772	7424559
PR21	Ophthalmia Dam	794257	7415934
PR22	Tower Hill	778663	7413664
PR23	Round Hill	783071	7404610
PR24	Hickman Crater	775106	7449800
PR25	Weeli Wolli Spring and Outfall	726288	7464069
PR26	Stuarts Pool	765881	7433047
PR27	Kalgan Pool	776023	7433093
PR28	Eagle Rock Hole	763923	7442594
PR31	Robertson Range	769235	7453385
PR32	Walgunya	717930	7442736
PR33	Jigalong	889310	7400884
PR34	Dales Camping Area	880740	7429256
PR35	Mount Bruce Lookout	886692	7411585

RECEPTOR ID-	SITE NAME	SITE LOCATION (EASTING Z50)	SITE LOCATION (NORTHING Z50)
PR44	Karijini Eco Retreat	630018	7523861
PR45	Wirrilimarra Community Area	681819	7546628

The assigned noise levels were predicted to be exceeded at two sensitive receptor locations:

- Marillana Homestead – the assigned level of 35 dB(A) was exceeded by 6.1 dB and 6.2 dB for the 30% Conceptual Development Scenario and Full Conceptual Development Scenario, respectively, with the main noise contribution predicted to come from third-party operations. BHP Billiton Iron Ore operations in isolation do not exceed the assigned levels at this receptor and contribute less than 1 dB to the cumulative noise level at this receptor location. The noise assessment confirms the implementation of the Strategic Proposal will not adversely impact this sensitive receptor but does identify the potential impact that other previously approved third-party operations are likely to have.
- Newman town centre – the assigned level of 35 dB(A) was exceeded by 3.2 dB and 3.3 dB for the 30% Conceptual Development Scenario and Full Conceptual Development Scenario, respectively, with the main contribution being from BHP Billiton Iron Ore operations in both instances.

The assigned levels of 60 dB(A) were not exceeded for sensitive receptors located in outdoor areas (e.g. recreational sites, lookouts, rest stops etc.). The highest predicted noise level for these receptor types was 43 dB(A), which is 17 dB below the threshold criteria.

Noise modelling predicts that Strategic Proposal mining noise impacts on sensitive receptors will be below the environmental assigned noise levels, except in the case of Newman town centre, where the criteria was exceeded by 3.3 dB. Eastern Ridge was identified as the mining operation that contributed the most to the predicted noise levels at this location. Note the predicted noise level in Newman town centre is based on high-level regional assumptions and not on detailed modelling of this existing operation. Future processing may not necessarily occur at this exact location, which has been used as a model only. In addition to this, it is important to note the predicted impacts are based on an assumption that standard noise control measures (as employed at Mining Area C and Orebody 24) will be used at BHP Billiton Iron Ore and third-party operations. This assumption incorporates a conservative approach to the modelled results, as it will allow the opportunity to realise further noise reductions where required during the implementation of specific operations.

As the modelling has been completed for development scenarios, verification during the implementation of the Strategic Proposal will identify the actual need for noise management measures in addition to standard practices. This assessment has shown that operations likely to impact Newman warrant more detailed investigation to accurately estimate noise emission levels for static and mobile equipment, as well as their accurate spatial distribution at a project level to refine and validate modelled results. In addition, the Tom Price town centre, Rhodes Ridge town site and Capricorn Roadhouse sensitive receptor locations are approaching the assigned noise level and may need to be assessed in more detail if the development scenario configurations change significantly (see Table 58 for predicted noise levels). Note, however, that, under the current scenario configurations, BHP Billiton Iron Ore contributions to the noise levels at Tom Price town centre are minimal.

Table 60 presents the predicted noise levels at selected sensitive receptor locations due to rail operations. The table contains the predicted noise levels for only the five highest receptors, with results for all sensitive receptor locations provided in Appendix 10. The cumulative modelling predicts the noise limit of 55 dB(A) and the noise target of 50 dB(A) will be satisfied at all assessed noise-sensitive receptor locations for all development scenarios. The modelling indicates that the Strategic Proposal will not result in a significant noise impact from current or future rail operations and does not approach the target or limit criteria at any of the assessed sensitive receptors.

Table 60: Predicted noise levels resulting from rail operations

Site Name and Description	Existing Development Scenario (predicted noise level in dB(A))	30% Conceptual Development Scenario (predicted noise level in dB(A))	Full Conceptual Development Scenario (predicted noise level in dB(A))	Assigned Noise Limit (Target) in dB(A)
Marillana Homestead	29.9	34.7	34.7	50 (55)
Newman town centre	29.7	31.7	31.7	50 (55)
Ophthalmia Dam recreation site	25.9	31.2	31.2	50 (55)
Tower Hill Lookout	30	32	32	50 (55)
Weeli Wolli Spring And Outfall recreation site	12.5	36.2	36.2	50 (55)

The outcome of the cumulative noise assessment indicates that acceptable noise levels can be maintained at a regional scale (Figure 61). The modelling of the 30% Conceptual Development Scenario and Full Conceptual Development Scenario has only identified one potential exceedance of the legislative noise criteria of 35 dB(A) at the Newman town centre (Receptor PR07) (Figure 62). All other noise-sensitive receptor locations were compliant with the noise criteria, except at Marillana Homestead where the exceedance was predicted to be caused by a third-party proponent and not significantly impacted by the Strategic Proposal.

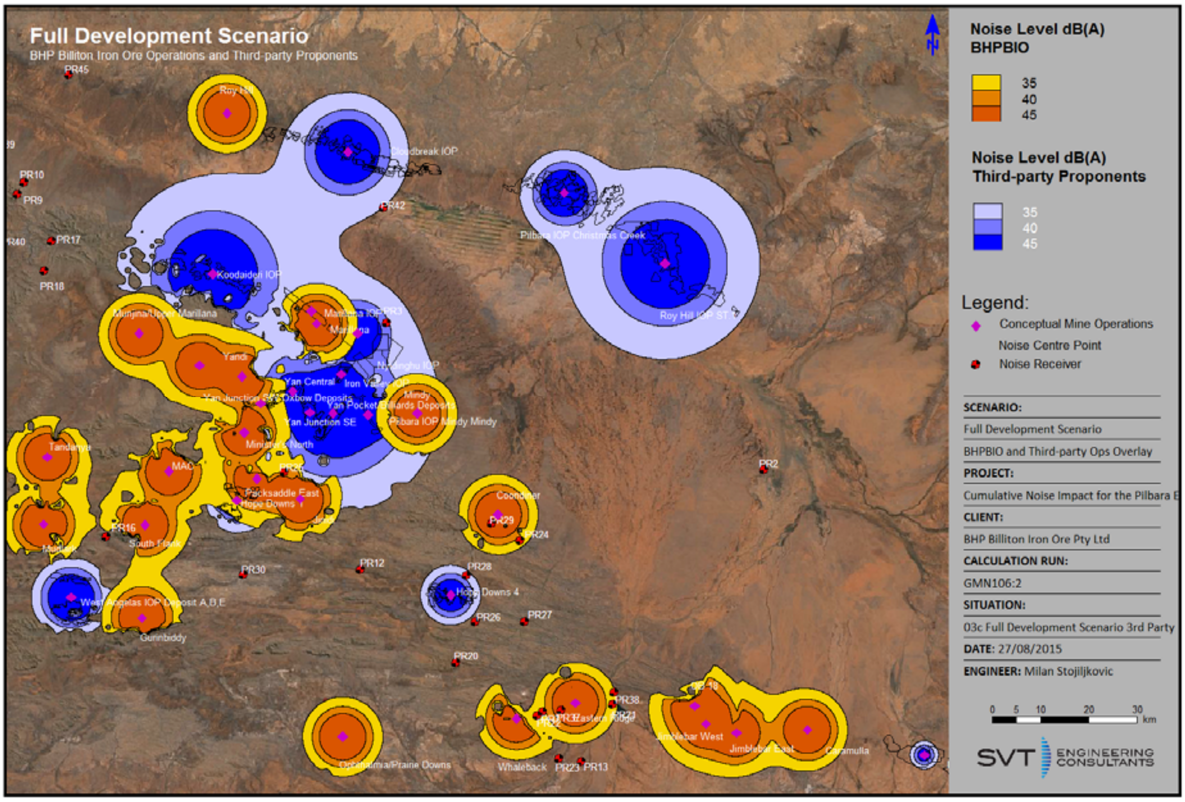


Figure 61: Cumulative noise model for Full Conceptual Development Scenario for BHP Billiton Iron Ore and third-party proponents

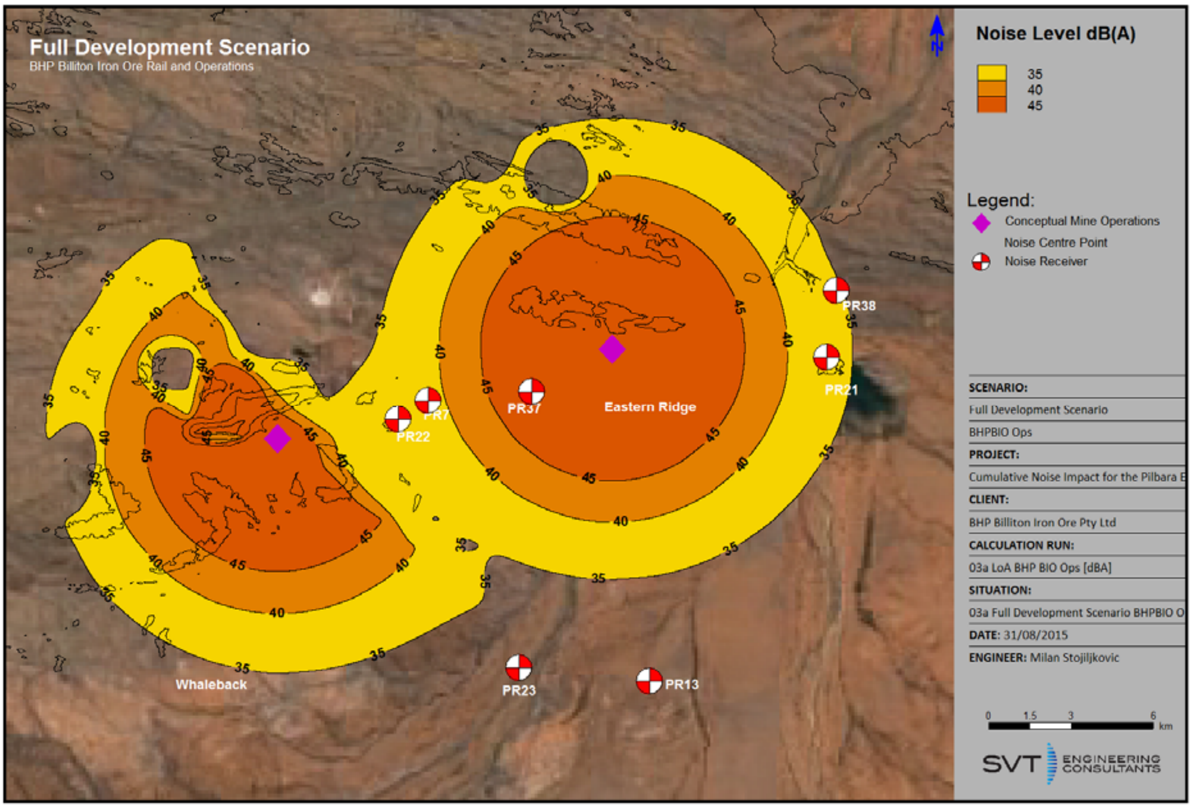


Figure 62: Noise contours depicting Newman operational hub and Eastern Ridge processing hub for the Full Conceptual Development Scenario, which yielded a potential noise criteria exceedance at the Newman town centre (PR07)

The noise assessments predict that impacts at the regional scale will be relatively low, both from BHP Billiton Iron Ore's development scenarios and cumulatively, where known future third-party developments were also considered. The potential landscape and receptor impacts have been identified at a strategic level and conservatively assessed. The Amenity Management toolkit allows the development of specified management options for operations in closer proximity to the township of Newman and to Marillana Homestead during the implementation of a Derived Proposal so significant impacts can be avoided.

BHP Billiton Iron Ore will also continue to look for efficiencies and improvements within its operations, such as the Yelloroll example (Case Study 9) to mitigate noise impacts where improvements are required. The management used at a local level will also reduce the inherent impacts at the regional scale.

8.3.6 SUMMARY OF ASSESSMENT OUTCOMES

In considering the EPA theme 'People', BHP Billiton Iron Ore has assessed the potential impact of the PERSP on Aboriginal heritage, European heritage, visual amenity and noise.

Aboriginal heritage and European heritage will continue to be managed via BHP Billiton Iron Ore's internal heritage management processes and will comply with requirements of the *Aboriginal Heritage Act 1972*, EPBC Act and the Heritage of Western Australia Act. Consequently, BHP Billiton Iron Ore has a high level of certainty that the EPA's factor objective for Heritage will be achieved.

Visual amenity was not considered a key environmental factor when the EPA provided its determination on the ESD; however, in recognition of potential societal impacts from its mining operations, BHP Billiton Iron Ore has assessed and discussed this factor in the PERSP.

Visual amenity impacts to regional landscapes are expected to be minimal. The following four key areas have the highest density of sensitive receptors for visual amenity

- **Newman, surrounding settlements and Ophthalmia Dam**: Visual impacts are not expected to be significant; the most likely potential impact would be to vegetation from groundwater changes.
- **Weeli Wolli Creek system:** No views of mining operations are expected from Weeli Wolli Creek.

- **Great Northern Highway:** As the highway predominantly runs through areas of low elevation, the contribution of vegetation cover to visual amenity impacts was found to be significant, and vegetation removal will likely be required for development.
- **Mount Meharry (Karijini National Park):** Karijini National Park's most iconic sites (gorges and rock pools) are located in the north and are generally very resilient to amenity impacts due to their very small viewsheds (being situated within gorges or valleys). The most likely visual impact would be to Mount Meharry, the tallest peak in the area.

BHP Billiton Iron Ore has applied the significance framework detailed in Environmental Guideline 9 (EPA 2015b) during the assessment of visual amenity and has found that the residual impact is anticipated to meet the EPA's factor objective with a high level of certainty that acceptable outcomes will be achieved.

Noise amenity was not considered a key environmental factor when the EPA provided its determination on the ESD; however, in recognition of potential societal impacts from its mining operations, BHP Billiton Iron Ore has assessed and discussed this factor in the PERSP.

Cumulative noise modelling identified two sensitive receptor locations where the assigned noise level was predicted to be exceeded:

- **Newman town centre:** The Strategic Proposal was found to be the key contributor.
- **Marillana Homestead:** Third-party operations were found to be the key contributors.

All other noise-sensitive receptor locations were compliant with the assigned noise level. As the noise assessment was based on standard noise control measures, there is opportunity for BHP Billiton Iron Ore to apply additional controls where required to achieve the assigned noise level.

BHP Billiton Iron Ore has applied the significance framework detailed in Environmental Guideline 9 (EPA 2015b) during the assessment of noise and has found that the residual impact is anticipated to meet the EPA's factor objective with a high level of certainty that acceptable outcomes will be achieved.

8.4 Air

8.4.1 INTRODUCTION

The EPA's determination on the Strategic Proposal referral identified Air Quality and Atmospheric Gases as a preliminary environmental factor under the theme of Air. The EPA identified cumulative and regional-scale impacts to air quality as a potential outcome of the Strategic Proposal if not assessed and managed appropriately. Although Air Quality was not identified as a key environmental factor for the PERSP within the ESD, BHP Billiton Iron Ore commissioned the development of an air quality model for the region and completed a cumulative impact assessment for a range of development scenarios. The PERSP summarises the key findings of the detailed technical study, which is provided in Appendix 9.

The climate and meteorological characteristics of the region will affect the dispersion, transformation and deposition of pollutants in the atmosphere. The semi-arid landscape of the Pilbara makes it a naturally dusty environment, with windblown dust a significant contributor to ambient particulate levels within the region. To ensure representative data were used to inform the cumulative air assessment, 11 years of meteorological data recorded in the region were reviewed to understand local climatology. For the purposes of defining the ambient air quality characteristics of the region, data from the BHP Billiton Iron Ore monitoring network were referenced to define background and existing air quality.

Given the nature of the environmental context and the relatively remote nature of the proposed operations, the strategic assessment focused on particulate (or dust) emissions to air and on greenhouse gases (GHGs). To assess the relative impact or significance of these emissions and the resulting ambient air quality concentrations, comparison was made to relevant West Australian or Australian environmental standards, guidelines and criteria.

This chapter is separated into assessment of particulates (Section 8.4.2) and assessment of GHGs (Section 8.4.3).

8.4.1.1 EPA FACTOR OBJECTIVES

BHP Billiton Iron Ore's outcome-based objectives for environmental factors are aligned with EPA objectives, as set out in EPA's Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015a). The EPA and BHP Billiton Iron Ore objectives for Air are provided in Table 61. The process used to demonstrate that environmental objectives will be met is aligned with the EPA's Environmental Assessment Guideline for the Application of a Significance Framework in the Environmental Impact Assessment Process (EPA 2015b).

Table 61: EPA and BHP Billiton Iron Ore objectives for Air

FACTOR	EPA OBJECTIVE (EPA 2015A)	BHP BILLITON IRON ORE OBJECTIVE[1]
Air Quality and Atmospheric Gases	To maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.	BHP Billiton Iron Ore shall mitigate risks to air quality and from atmospheric gases from its activities to an acceptable level.

1. 'Acceptable level' is defined as per the EPA's significance framework in Environmental Assessment Guideline 9 (EPA 2015b); thus BHP Billiton Iron Ore considers an 'acceptable level' of impact to be a level of residual impact that meets the EPA's objectives for that environmental factor.

8.4.1.2 KEY LEGISLATION AND GUIDANCE

As discussed in Section 7.1, BHP Billiton Iron Ore has addressed applicable legislation, policy and guidance for each factor. The materials relevant for the consideration of Air are detailed in Appendix 1, Table 1.4.

8.4.1.3 AIR EMISSIONS MANAGEMENT TOOLKIT

BHP Billiton Iron Ore's management toolkit for air emissions is presented in Figure 63. The measures presented are not exhaustive, and additional management measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied on a merit-based approach.

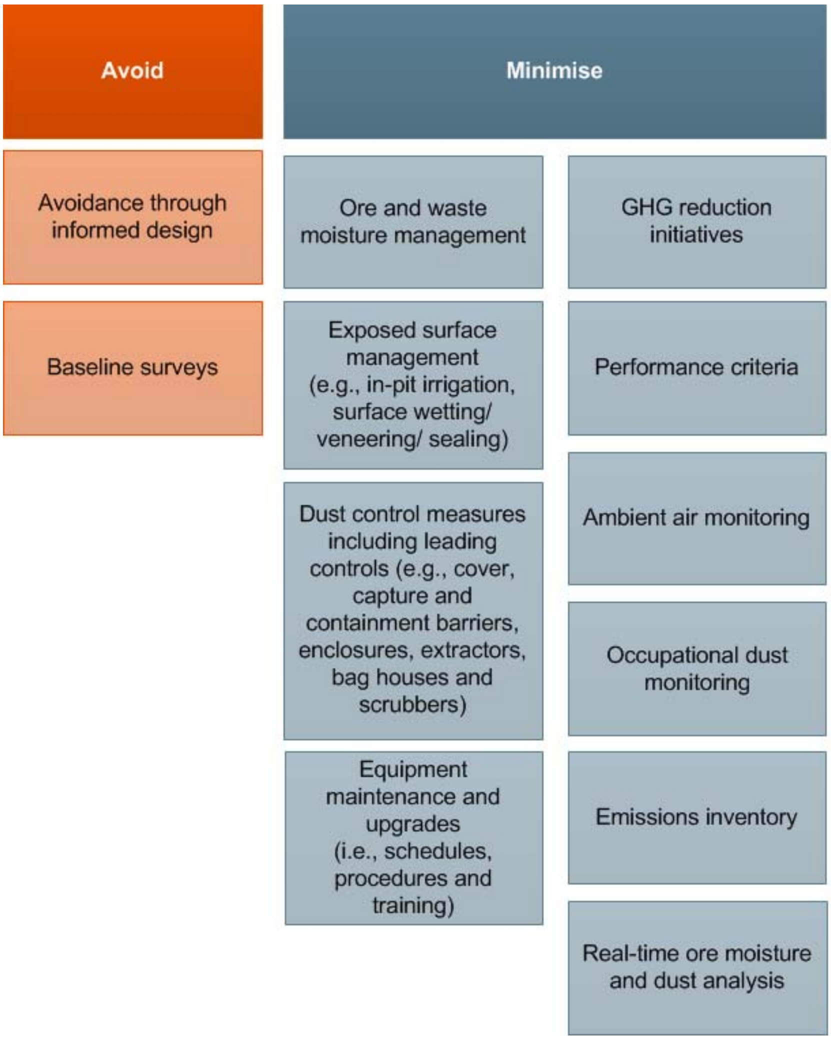


Figure 63: BHP Billiton Iron Ore's Air Emissions Management Toolkit

Leading Controls are proposed as management options where required. These controls are adaptive and are based on review of various documents including the NPI manuals and standards specified in Appendix 1, Table 1.4.

8.4.2 PARTICULATES ASSESSMENT

8.4.2.1 EXISTING ENVIRONMENT

The semi-arid nature of the Pilbara makes it a naturally dusty environment. Windblown dust is expected to be a significant contributor to the ambient dust levels in the area. The projections for the future climate of the Pilbara region generally predict a hotter and drier climate (Loechel et al. 2011), which is likely to exacerbate ambient dust concentrations in the future.

Sensitive Receptors

A particulate modelling assessment was undertaken to identify the exposure to particulates at potential sensitive receptors within the Project Definition Boundary. The assessment considered the following sensitive receptor locations in the model:

- Aboriginal community –Wirrilimarra Community Area;
- homestead – Juna Downs, Ethel Creek, Marillana, Mulga Downs, Prairie Downs, Sylvania;
- lookout – Munjina East Gorge, Fig Tree Crossing, Mount Meharry, Mount Newman, Tower Hill;
- recreation camp site – Karijini Eco Retreat;

- recreation site – Ophthalmia Dam, Round Hill, Hickman Crater, Weeli Wolli Spring and Outfall, Stuarts Pool, Kalgan Pool, Eagle Rock Hole;
- rest stop – Mount Robinson;
- roadhouse – Munjina Roadhouse, Auski Village, Capricorn Roadhouse;
- town centre – Newman; and
- town site – Rhodes Ridge.

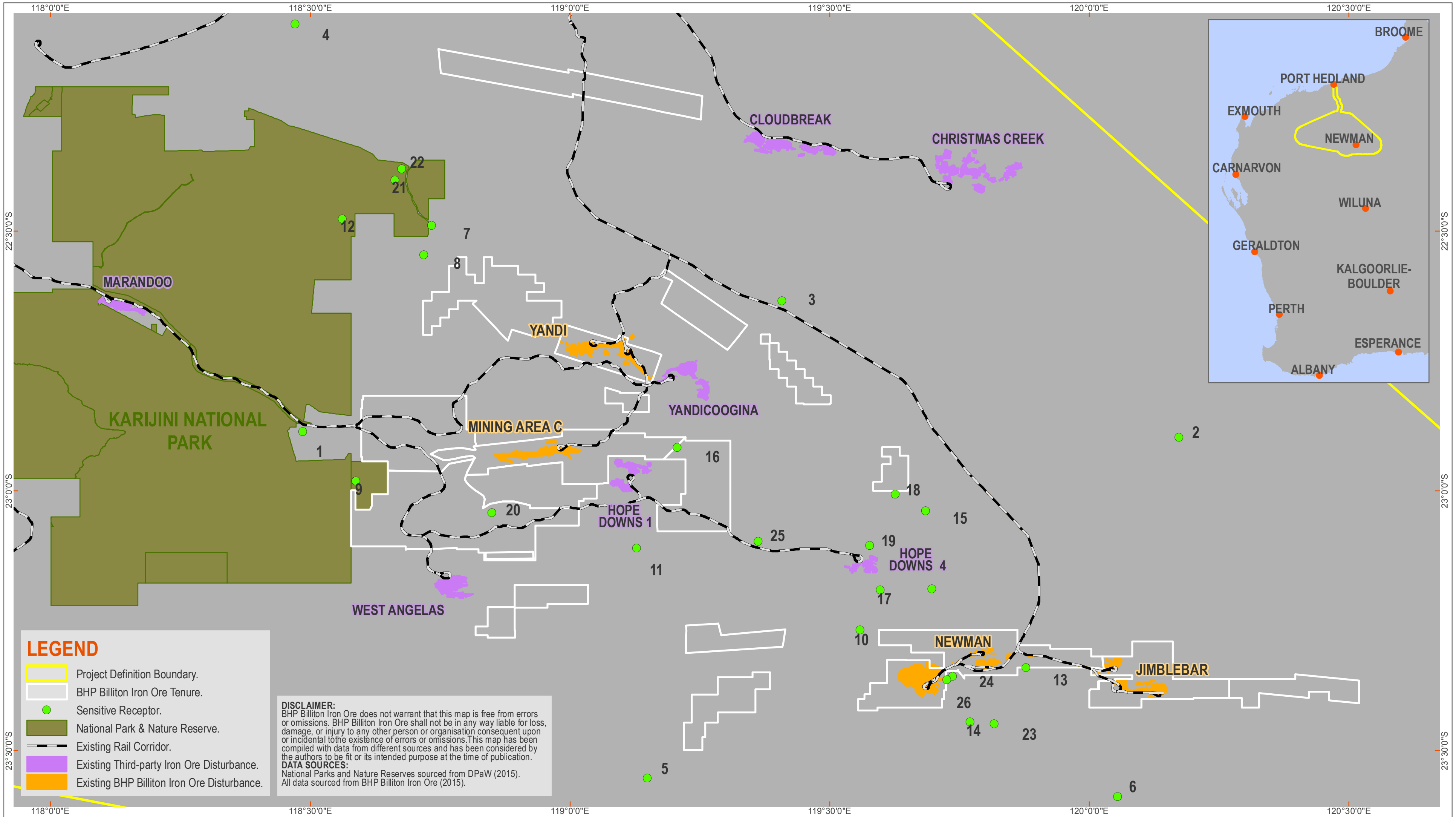
The locations of these sensitive receptors are presented in Table 62 and Figure 64. Note that there are 14 recreational sites, rest stops and lookouts where people congregate only intermittently that are treated as sensitive receptors in this conceptual model.

Table 62: Sensitive receptor locations for air quality

Receptor ID	Easting (m)	Northing (m)	Name	Type
1	652,321	7,468,375	Juna Downs	Homestead
2	825,483	7,464,467	Ethel Creek	Homestead
3	747,479	7,495,073	Marillana	Homestead
4	651,662	7,555,182	Mulga Downs	Homestead
5	719,290	7,393,667	Prairie Downs	Homestead
6	811,750	7,388,078	Sylvania	Homestead
7	678,283	7,512,021	Munjina East Gorge	Lookout
8	676,697	7,505,825	Fig Tree Crossing	Lookout
9	662,753	7,457,807	Mt Meharry	Lookout
10	761,772	7,424,559	Mt Newman	Lookout
11	778,663	7,413,664	Tower Hill	Lookout
12	630,018	7,523,861	Karijini Eco Retreat	Recreation camp site
13	794,257	7,415,934	Ophthalmia Dam	Recreation site
14	783,071	7,404,610	Round Hill	Recreation site
15	775,106	7,449,800	Hickman Crater	Recreation site
16	726,288	7,464,069	Weeli Wolli Spring/Outfall	Recreation site
17	765,881	7,433,047	Stuarts Pool	Recreation site
18	776,023	7,433,093	Kalgan Pool	Recreation site

RECEPTOR ID	EASTING (M)	NORTHING (M)	NAME	TYPE
19	763,923	7,442,594	Eagle Rock Hole	Recreation site
20	689,526	7,450,659	Mt Robinson	Rest stop
21	671,172	7,521,766	Munjina Roadhouse	Roadhouse
22	672,582	7,524,176	Auski Village	Roadhouse
23	787,812	7,404,112	Capricorn Roadhouse	Roadhouse
24	779,758	7,414,360	Newman	Town centre
25	742,012	7,443,807	Rhodes Ridge	Town site
26	681,740	7, 546,480	Wirrilimarra Community Area	Aboriginal community

These receptors were assessed against the National Environment Protection (Ambient Air Quality) Measure (Air NEPM) standard and Port Hedland Industries Council Taskforce (the Taskforce) PM_{10} guideline to provide a conservative indicative dust impact.



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Strategic Proposal

Figure 64 Sensitive receptor locations (air emissions)

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Kilometres

bhpbilliton
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The Air NEPM sets national standards for the six key air pollutants to which most Australians are exposed: carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particles as PM_{10}. Under the Air NEPM, all Australians have the same level of air quality protection. In addition to the Air NEPM standard, BHP Billiton Iron Ore is required to meet the Taskforce PM_{10} guideline (DSD 2010). The resultant PM_{10} criteria are provided in Table 63.

Table 63: Ambient PM_{10} criteria for BHP Billiton Iron Ore operations

Source	Substance	Standard or Guideline (μg/m³)	Averaging Period	Maximum allowable exceedances per year
Air NEPM	PM_{10}	50	24-hour	5 allowed exceedances
Taskforce	PM_{10}	70	24-hour	10 allowed exceedances

In the absence of regulations for total suspended particulates (TSP) specific to the region, the Kwinana Environmental Protection Policy (EPP) has been used as the standard and limit for TSP, as shown in Table 64.

Table 64: Ambient TSP standard and limit used in the air assessment

Guidance	Substance	Standard (μg/m³)	Limit (μg/m³)	Averaging Period
Kwinana EPP	TSP	90	150	24-hour

Climate and Meteorological Data

The climate of the central Pilbara is arid to tropical, characterised by high temperatures, high evaporation rates, occasional intense rainfall and regular cyclonic activity. There are two major seasons: hot summers (October to April) when the majority of rainfall occurs and mild, relatively dry winters (May to September). The weather is largely controlled by the seasonal oscillation of an anti-cyclonic belt (high-pressure system) in the subtropics. With the Strategic Proposal being located in the central Pilbara region, it is likely to be affected by dispersion characteristics typical of an inland environment, including:

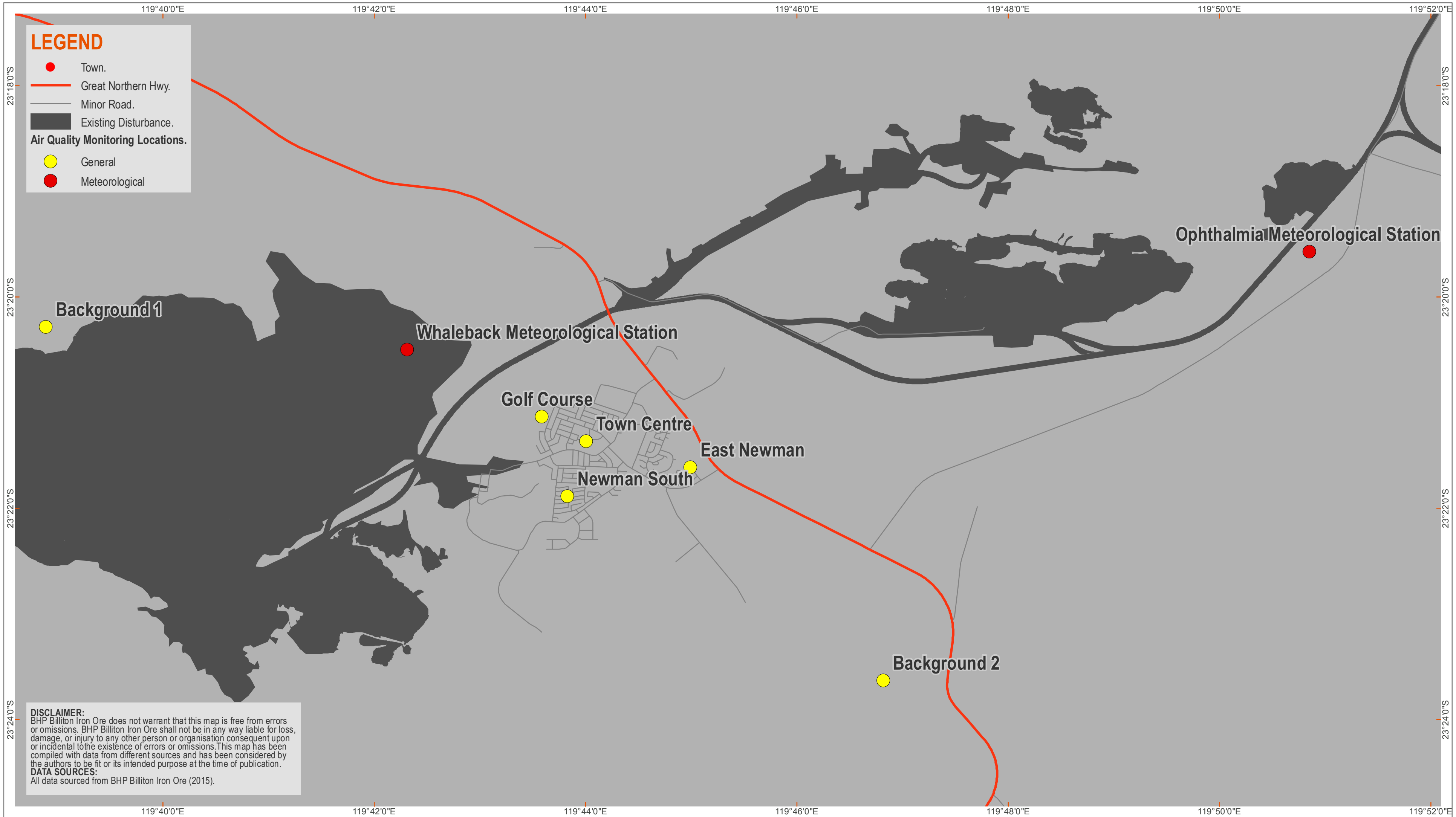
- unstable (or convective) atmospheric conditions in daytime; and
- stable atmospheric conditions dominating at night and in the early morning hours.

Meteorological data obtained included average hourly wind speed, wind direction and temperature, rainfall and humidity. The analysis of the data included wind roses, diurnal temperature profiles and atmospheric stability classifications. The meteorological data are provided in Appendix 9. The data analysis provided an understanding of the local climate and informed the emission estimations and dispersion model set-up. Analysis of meteorological data was also used to identify a representative year for dispersion modelling.

Existing Ambient Particulate Concentrations

Data for the Background 2 monitoring station (location shown in Figure 65) was reviewed for the period 2009 to 2012. This review gave consideration to both 10-minute and 24-hour average data. The data provide a general description and understanding of the local air quality (based on existing emission sources). The total suspended particulates (TSP) and PM_{10} dust concentrations recorded at Background 2 between January 2009 and December 2012 are presented in Figure 66.

Elevated particulate concentrations, especially TSP, were observed in 2009. Although the specific cause is unknown, a possible reason for these high annual concentrations is the contribution by wildfires. In addition, 2009 and 2012 recorded moderate data recovery (i.e. below 90%). Therefore neither of these two years should be considered to be a representative year for background particulate concentrations.



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Strategic Proposal

Figure 65 BHP Billiton Iron Ore air quality monitoring network at Newman

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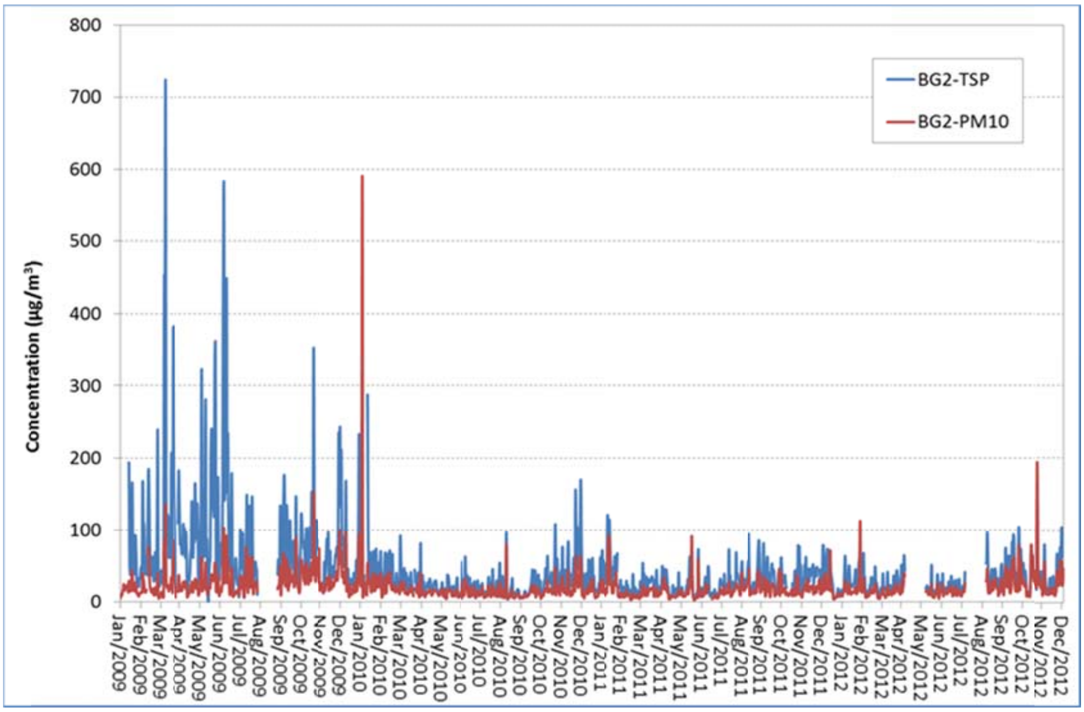


Figure 66: TSP and PM_{10} concentrations at Background 2 monitoring station (2009 to 2012)

Based on the analysis to inform the air quality modelling, the annual average concentrations of PM_{10} and TSP were slightly higher in 2010 than in 2011. Therefore, using a conservative approach, the data from 2010 were used as the background concentrations for this assessment. A background TSP concentration of 33 $\mu g/m^3$ and a background PM_{10} concentration of 18 $\mu g/m^3$ are considered to be reflective of the region.

Mining Operation Emissions

Particulate emission estimates for existing mining operations (BHP Billiton Iron Ore and third-party) are presented in Table 65.

Table 65: Estimated emissions for existing mining operations

MINING OPERATION	PM_{10} (TPA)	TSP (TPA)
BHP Billiton Iron Ore		
Mining Area C	8,992	25,717
Orebody 18	2,159	6,175
Mt Whaleback	5,389	15,413
Eastern Ridge	2,751	7,868
Yandi	10,863	31,069
Jimblebar	2,279	6,517
Total	**32,433**	**92,759**

Mining Operation	PM_{10} (tpa)	TSP (tpa)
Third Party		
Christmas Creek Operations	16,100	46,046
Cloudbreak Operations	15,206	43,488
Hope Downs 1 Mine	3,768	10,777
Hope Downs 4 Mine	311	889
Marandoo Mine	1,249	3,571
West Angelas Mine	2,826	8,084
Yandicoogina Mine	2,978	8,517
Total	**42,438**	**121,372**
Grand total	**74,871**	**214,131**

Background Ambient Air Quality

BHP Billiton Iron Ore has an existing ambient air quality monitoring network in the vicinity of its eastern Pilbara operations. The current network consists of six ambient air quality monitoring stations and two meteorological stations (see Figure 65). Siting of the stations was intended to measure a mixture of background dust concentrations (or regional dust concentrations) and the potential impact of the operations at indicative sensitive receptor locations (Newman). An analysis of the data suggests that all of the air quality monitoring stations are influenced by existing operations, with the exception of Background 2, which is located approximately 5 km southeast of Newman township. The Background 2 monitoring station is not expected to be impacted by mining activities in the region due to its distance from the mining operations and the prevailing wind direction during the year. Therefore, the background ambient air quality in this assessment has been determined solely from Background 2.

For the purposes of defining ambient air quality characteristics of the region, data from the monitoring network have been reviewed and summarised. The review identified the year 2010 as the most representative of the average ambient air quality conditions.

BHP Billiton Iron Ore commissioned a strategic air quality assessment to determine the existing air quality and to allow the examination of potential impacts of the Strategic Proposal at a regional scale (Appendix 9). This assessment used modelling guidelines issued by the Department of Environment Regulation (DER) and the EPA (DoE 2006) for assessing air quality impacts through dispersion modelling. A variety of modelling software could potentially be used; the commissioned study used CALPUFF (California puff model). A description of the ‘plume’ and ‘puff’ models is provided in Box 4.

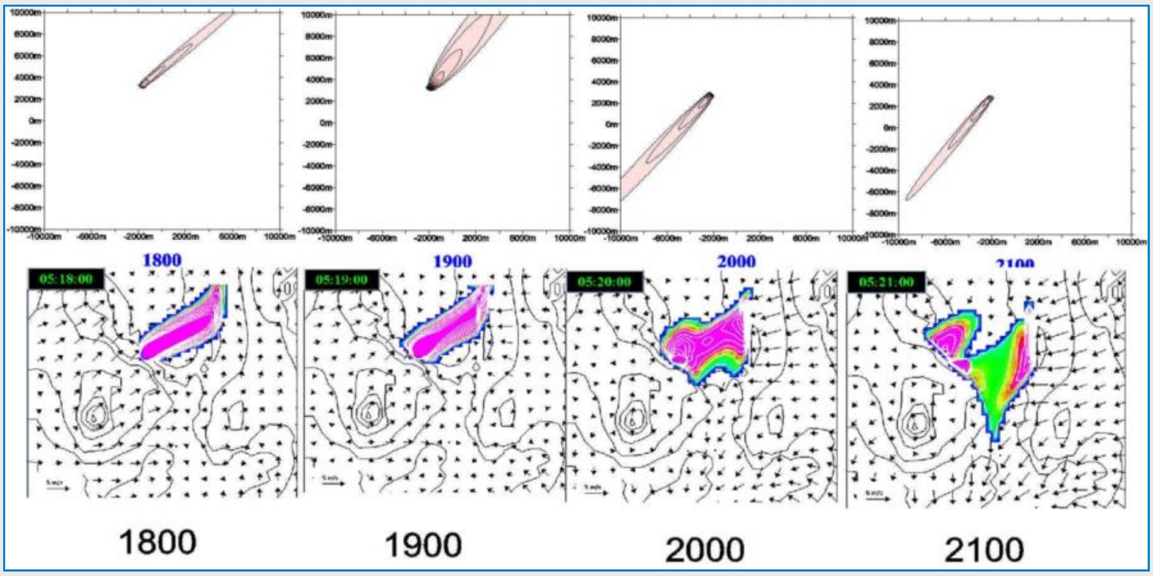
Box 4: “Plume” verses “Puff” models

The suites of air quality models that are commonly used in Australia include AERMOD, AUSPLUME and CALPUFF. While AERMOD and AUSPLUME are based on an assumption of steady-state meteorology (generically known as ‘plume models’), CALPUFF is based on non-steady-state meteorology (‘puff model’).

Plume models assume instantaneous, straight-line transport of emissions between source and receptor based on hourly averaged wind speed and direction data. For that reason, they are described as steady-state models: plume calculations for one hour assume a meteorological field that is constant in time and space and contain no memory of what happened in previous hours. Plumes can appear to travel unrealistic distances in a straight line when winds are light and variable.

Non-steady-state models (including puff models) track discrete parcels of emissions as they move with the wind. They calculate variable dispersion depending on position of the puff within the model domain and the corresponding local flow conditions.

An illustration of how the formulation of the two types of models can lead to substantial differences in predicted emission transport behaviour is presented below.



The top sequence was generated by a steady-state model, the lower sequence by a non-steady-state model. The same times and emissions source locations have been used. In the lower sequence, arrows indicate surface wind, and black lines are terrain contours. The non-steady-state solution evolves as the wind field changes in both time and space. The figure demonstrates an hourly sequence and shows the differences between steady-state and non-steady-state models in conditions of changing winds and terrain influences.

The model configuration used for the PERSP and the various inputs into the model are detailed in Appendix 9.

Meteorology

Meteorology is a critical component and input to a regional dispersion model. Meteorology of the region was characterised by analysing measurements from on-site and nearby weather data recorded by BHP Billiton Iron Ore and the Bureau of Meteorology. Recorded wind speed and direction, temperature, humidity, rainfall and evaporation data were analysed. For the purposes of understanding the local climate, an 11-year dataset of meteorological parameters recorded in the region was reviewed.

Previous dispersion modelling studies in the Pilbara have used the CSIRO-designed model TAPM to predict the meteorology used as input into atmospheric modelling studies. Concerns have been raised about the suitability of TAPM due to its known limitations, namely over predicting the occurrence of light winds and an inability to predict high wind speeds. In the context of the Pilbara, these are critical limitations, particularly for assessments where dust estimates are based on wind influences.

To provide a representative and technically robust model (and therefore model outcomes), the Weather Research and Forecasting (WRF) model was coupled with CALPUFF. WRF is a numerical weather prediction system, primarily designed to serve both operational forecasting and atmospheric research. CALPUFF is an advanced modelling system for the simulation of atmospheric pollution dispersion.

For the strategic assessment, the WRF-processed meteorological data, both surface and upper air, was used as an input to CALMET (a diagnostic 3-dimensional meteorological model) for further processing down to the fine scale used in the CALPUFF dispersion modelling.

Source Characteristics

For the purposes of emission estimation and inclusion in the dispersion modelling, the Existing Development, 30% Conceptual Development and a Full Conceptual Development scenarios have been utilised. It is highly unlikely that the Full Conceptual Development Scenario will occur in reality; however, it has been presented to provide a conservative worst-case prediction for cumulative impact assessment purposes.

Fourteen mining operations were used to represent current emissions, 28 mining operations were used to represent emissions for the 30% Conceptual Development Scenario and 37 mining operations were used to represent emissions for the Full Conceptual Development Scenario, as shown in Figure 67, Figure 68 and Figure 69 respectively. Note that the mining operations may include more than one emissions source allocation.

Operation Emissions Determination

To model predicted air quality, emissions rates and characteristics from point and area sources are required. For this assessment, emissions for existing and future operations were defined using a consistent estimation method across all sites. Emissions from existing BHP Billiton Iron Ore operations have been primarily based on historic, site-specific data where they exist. In the absence of site-specific data, reference has been made to the National Pollution Inventory (NPI) reporting.

For the third-party operations, emissions are based on published NPI data. The emission sources are defined as constant-rate area sources for the whole site based on the latest disturbance area. Where possible, these data were verified with published stripping ratios for individual mines, as well as tonnage and disturbance footprint data in the Pilbara region. Emissions from each operation included such activities and sources as:

- haul road;
- loading and unloading (ore and waste);
- wind erosion;
- blasting;
- crushing or screening;
- stacking or reclaiming;
- rail load-out; and
- miscellaneous transfers.

This technique provided an emission estimate for existing operations, with source apportionment data from previous emission estimation and modelling studies used to determine the contribution from each of the activities listed above to the total emission rate. Information on the output for each existing operation (ore and waste) enabled the relationship between the total tonnes mined and a site emission rate to be determined. This relationship was used to support the estimation of emissions from future mines to be included in the assessment.

For modelling purposes, it is imperative that all emission sources from a facility (existing and proposed) are identified and that all emissions are calculated. If this is not done, the emissions will be underestimated and the potential impacts will be under predicted. Emission estimation and subsequent benchmarking with existing operations has verified the similarities between the proposed emission estimation method and a more detailed site-specific emission estimation method (PEL 2012, 2013, 2014).

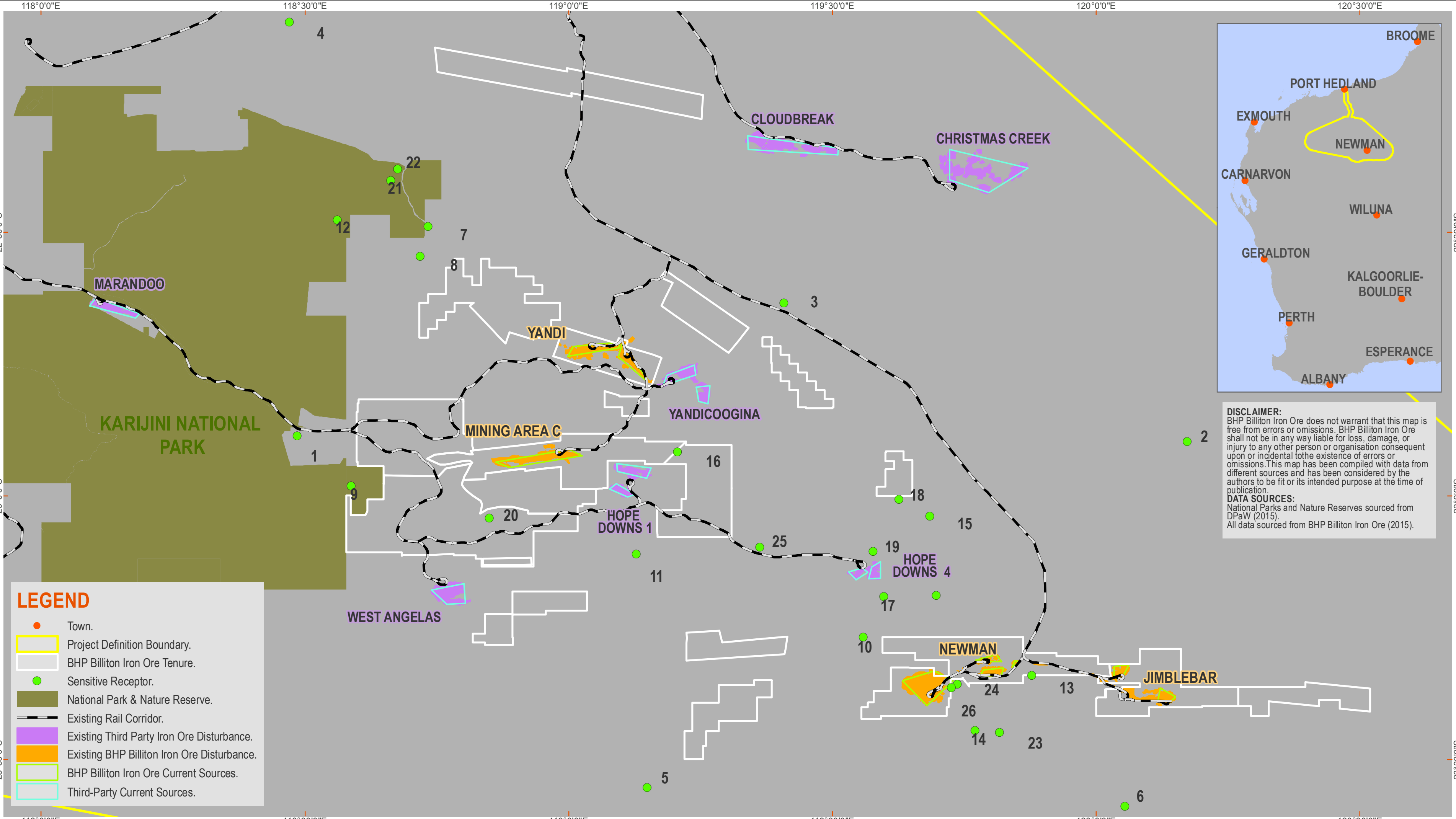


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Figure 67 Air emission source locations -Existing Development Scenario

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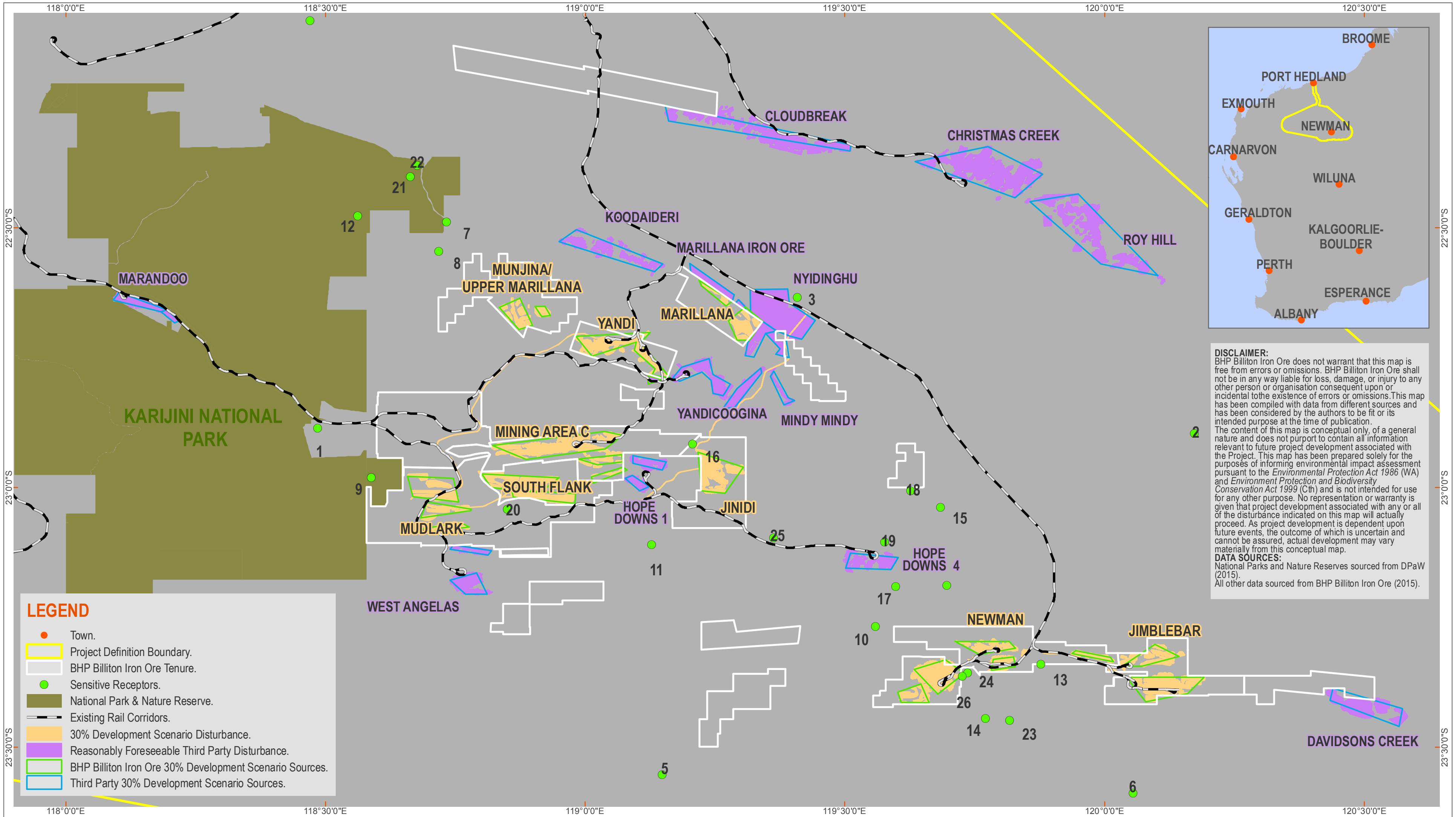
Environmental Approvals



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Strategic Proposal

Figure 68 Air emission source locations - 30% Conceptual Development Scenario

N

0 7.5 15 30 45 60
Kilometres

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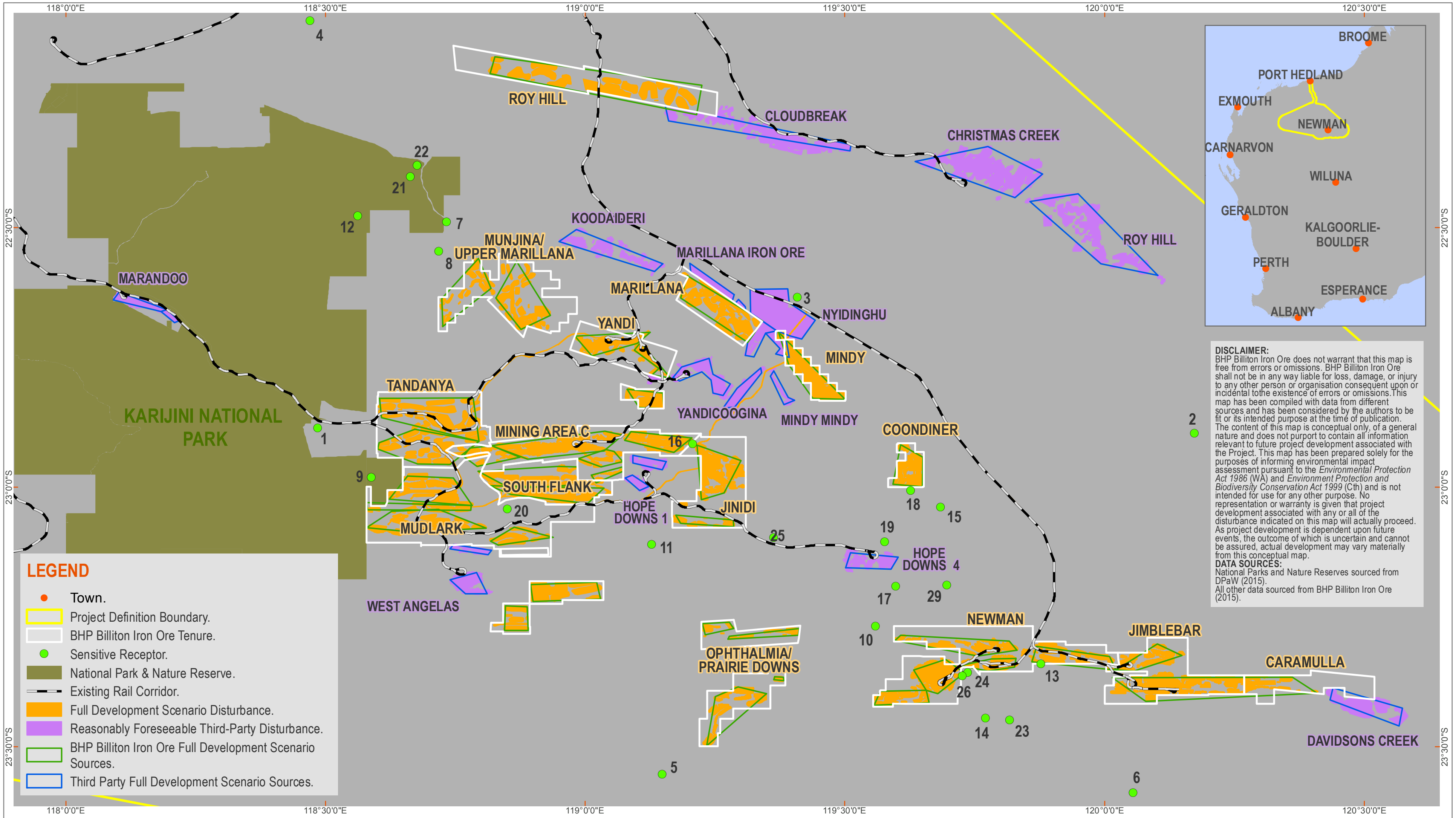

Public Environmental Review
Strategic Proposal

Figure 69 Air emission source locations - Full Conceptual Development

0 7.5 15 30 45 60
Kilometres

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Environmental Approvals

8.4.2.2 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara relevant to the potential impacts resulting from air emissions are listed in Table 66. A brief description of each potential impact is also provided.

Table 66: BHP Billiton Iron Ore's activities and their potential impacts associated with particulates.

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Pre-clearing works and construction of infrastructure	Pre-clearing works and construction of infrastructure can result in dust being generated usually it is not long term. This can impact sensitive receptors that are nearby, but are usually limited to daytime activities.
Mining activities during operations	Mining operations can create dust through activities such as blasting, mining, ore processing and transport. This can impact sensitive receptors that are nearby or impact visual amenity. Dust-sensitive vegetation may also be impacted.

8.4.2.3 MITIGATION

BHP Billiton Iron Ore has a suite of onsite mitigation measures that can be applied to mitigate impacts associated with particulate emissions and therefore contribute to achieving the outcome-based objectives for Air Quality and Atmospheric Gases (Figure 52). The mitigation measures relevant to mitigating impacts associated with particulate emissions are shown in the Amenity Management toolkit (Figure 52) and the Air Emissions Management toolkit (Figure 63). Leading Controls are proposed to be implemented to manage air emissions. Leading Controls were identified based on review of various documents including the NPI manuals and USEPA AP-42 documents, some examples are included in Table 67.

The management measures presented are not exhaustive; additional measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied on a merit-based approach, in accordance with BHP Billiton Iron Ore's adaptive management approach. An example of the application of the Amenity Management and Air Emissions toolkits for particulate emissions is provided in Table 68.

Table 67 Summary of control factors for dust control in the Pilbara region

OPERATION	DUST CONTROL METHOD AND EMISSION REDUCTION
Mining	
Bulldozing	No control
Loading ore and waste	Standard: no control Leading: 50% for water sprays in specific pits
Loading ore from ROM pad to crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Unloading waste	No control
Unloading ore at ROM pad	No control
Unloading ore into crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Drilling	Standard: 50% for cyclone Leading: 99% for water injection
Blasting	No control
Wind Erosion in OSA and ROM pad	Standard: 50% for water sprays Leading: 90% for chemical surfactant and good housekeeping
Haul road	
Hauling	Standard: 50% for level 1 watering (2 litres/m^2/h) Leading: 90% for chemical dust suppressant
Processing facility	
Unloading ore into primary crusher	Standard: 50% for water sprays Leading : 85% for water sprays and wind shield
Primary crushing of ore	Standard: 50% for water sprays Leading: 83 % for extraction
ROM stacker	Standard: 30% for boom sprays Leading: 30% for boom sprays
Screening plant	Standard: 40% for extraction Leading: 83% for extraction with fabric filters
Transfer station	Standard: no control Leading: 50% for water sprays (including BWS)
Stackers	Standard: 30% for boom sprays Leading: 30% for boom sprays
Train load out	Standard: 30% for water sprays Leading: 30% for water sprays
Wind erosion in open area	Standard: 50% for water Leading: 90% for chemical surfactant and good housekeeping

Table 68: Potential management approaches for particulate emissions

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Pre-clearing works and construction of infrastructure	• *Avoidance through informed design* by minimising clearing to the smallest area possible. • Minimise dust generation by *ore and waste moisture management*. • *Rehabilitate* cleared areas, progressively where possible, thus minimising surface area with potential for exposure as dust. • *Monitor* ambient air and occupational dust levels and report and manage as required.
Mining activities during operations	• *Avoidance* or *minimisation through informed design* by locating dust-generating activities away from sensitive receiver locations. • Minimise dust generation by *ore and waste moisture management*. • Minimise dust generation by *reducing the exposed ore surface area* or by *implementing dust control measures*, such as barriers. • *Rehabilitate* cleared areas, progressively where possible, thus minimising surface area with potential for exposure as dust. • *Monitor* ambient air dust levels and report and manage as required. Undertake appropriate *baseline surveys* to identify and avoid sensitive environmental ecosystems or components.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

Dust control continues to be a major operational focus of the business. BHP Billiton Iron Ore continues to maintain its extensive air monitoring network across its Pilbara operations and in Port Hedland and Newman. Results from these networks continue to be made publicly available. Key initiatives carried out during the 2014 financial year included the installation of four new additional monitoring stations in Newman, further expanding the Company's boundary monitoring network, and installation of a boundary monitoring network at port operations. BHP Billiton Iron Ore has established a real-time dust monitoring and modelling (and predictive modelling) system at its Port Hedland operations to actively monitoring and manage the potential for dust production. BHP Billiton Iron Ore has the ability to alter operations continuously to adapt to changing environmental conditions. The predictive model provides a 3-day forecast to manage operations further into the future.

Refer to Section 8.4.3.3 and Section 8.4.4 for further detail on the management of dust and air emissions.

8.4.2.4 SIGNIFICANCE OF IMPACTS

The air quality assessment completed for the Strategic Proposal has evaluated the potential cumulative air quality impacts within the Project Definition Boundary for the Existing Development Scenario, 30% Conceptual Development Scenario and Full Conceptual Development Scenario. The cumulative air quality assessment for the Full Conceptual Development Scenario is conservative as it is unlikely that all BHP Billiton Iron Ore mining and third-party operations will be operational at the conceptual maximum rate at the same time. The most likely case is that future mining operations will slowly progress and increase as existing mining operations slowly ramp down.

The purpose of this strategic modelling assessment was to assess likely impacts of the Strategic Proposal to determine the acceptability of and environmental outcomes to be achieved by future Derived Proposals. The 24-hour assessment criteria used provides a conservative analysis, as some receptor locations are recreational or intermittently visited and are not occupied for the entire period, therefore reducing exposure and associated health or amenity impacts. Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors.

The PM_{10} and TSP emissions attributed to future BHP Billiton Iron Ore mining operations are presented in Table 69. These emissions are assumed to be identical for each mining operation and quantify the potential range of emissions based on the level of management implemented. Emissions for future third-party mining operations are summarised in Table 70 and are based on the maximum approved production capacity with standard management controls in place, assuming consistent emission reduction outcomes as with the BHP Billiton Iron Ore operations.

Table 69: Estimated emissions for future BHP Billiton Iron Ore mining operations

Temporal Scenario	Ore and waste (Mtpa)	PM_{10} emission (tpa)			TSP emission (tpa)		
		No control	Standard control	Leading control	No control	Standard control	Leading control
Values assigned to each BHP Billiton Iron Ore mining operation	90	15,147	8,208	2,610	43,320	23,475	7,465
30% Conceptual Development Scenario	1,080	181,764	98,496	31,320	519,840	281,700	89,580
Full Conceptual Development Scenario	1,980	333,234	180,576	57,420	953,049	516,447	164,221

Table 70: Estimated emissions for future third-party mining operations

Facility	Ore and waste (Mtpa)	PM_{10} emission (tpa)	TSP emission (tpa)
Cloudbreak	260	23,712	67,816
Davidsons Creek	60	5,472	15,650
Hope Down 4	73	6,621	18,936
West Angelas	132	12,038	34,430
Hope Down 1	66	5,992	17,137
Marandoo	88	8,026	22,953
Yandicoogina SW Oxbow	36	3,324	9,507
Yandicoogina SE	32	2,955	8,451
Phils Creek	49	4,432	12,676
Iron Valley	14	1,277	3,652
Marillana	34	3,119	8,920
Koodaideri	126	11,491	32,865

FACILITY	ORE AND WASTE (MTPA)	PM_{10} EMISSION (TPA)	TSP EMISSION (TPA)
Roy Hill	361	32,960	94,265
Christmas Creek	234	21,341	61,035
Mindy Mindy	72	6,566	18,780
Nyidinghu	120	10,944	31,300
Total	**1,757**	**160,270**	**458,373**

The predicted impacts for the development scenarios are summarised below. More detail is contained in the technical report provided in Appendix 9.

When considering the following impacts, it is worth noting that 14 of the 26 sensitive receptors considered by this assessment are recreational sites, rest stops or lookouts (see Table 62). It is therefore reasonable to assume that people will only congregate intermittently at these locations, whereas the assessment criteria assumes a continual exposure for 24 hours. Therefore, considering these locations to be sensitive receptors in this conceptual model adds to the conservative nature of the assessment. Furthermore, it is important to recognise the contribution of third-party operations, which is discussed below. The modelling conducted for the conceptual development scenarios establishes with confidence that dust management controls can be successfully applied to ensure that emissions from BHP Billiton Iron Ore mining operations are maintained within acceptable parameters.

Existing Development Scenario

PM_{10}

Modelling indicates that the existing BHP Billiton Iron Ore mining operations (i.e. excluding third-party mining operations) have the potential to impact air quality with predicted exceedances of the PM_{10} Air NEPM and Taskforce criteria at two sensitive receptors, Tower Hill and Newman. At these two receptors, spikes in the data suggest these events are associated with certain meteorological conditions.

Existing emissions from third-party mining operations (i.e. excluding BHP Billiton Iron Ore mining operations) do not cause the PM_{10} Air NEPM or Taskforce criteria to be exceeded.

When the emissions from existing third-party and BHP Billiton Iron Ore mining operations are modelled together, the cumulative impacts are similar to the BHP Billiton Iron Ore only case, with exceedances of both the Air NEPM standard and Taskforce guideline at Tower Hill and Newman receptors. At the Tower Hill receptor, in comparison to the BHP Billiton Iron Ore only scenario, no change in maximum concentration is noted for the cumulative scenario. At the Newman receptor, in comparison to the BHP Billiton Iron Ore only scenario, there is a slight increase in the 90th percentile PM_{10} concentration, and there are two additional days when 24-hour PM_{10} concentrations are greater than the Air NEPM standard. Modelling predicts that there will be 47 days and 14 days where the Air NEPM standard and Taskforce guideline are exceeded in Newman, respectively. Although the model does not differentiate between natural and mine-related dust events, results generally align with monitoring conducted in Newman, which concludes that elevated dust levels due to mining activities currently occur.

TSP

Consistent with the PM_{10} modelling, an assessment of the existing BHP Billiton Iron Ore mining operations (i.e. excluding third-party mining operations) predicted air quality impacts with 24-hour maximum TSP concentrations higher than the assessment criteria at two sensitive receptors – Tower

Hill and Newman – and higher than the Kwinana EPP limit at Tower Hill. An assessment of the third-party mining operations (i.e. excluding BHP Billiton Iron Ore mining operations) did not cause the Kwinana EPP standard or limit to be exceeded at any of the sensitive receptors identified.

The cumulative impacts of modelled emissions from existing BHP Billiton Iron Ore and third-party mining operations predicted exceedances of the Kwinana EPP standard at Tower Hill and Newman and of the Kwinana EPP limit at Tower Hill. At the Tower Hill receptor, in comparison to the BHP Billiton Iron Ore only case, there was a slight increase in the 95th percentile TSP concentration. At the Newman receptor, there was no change in the TSP concentration when compared to the levels predicted to occur for the BHP Billiton Iron Ore only case, with 20 days where the Kwinana EPP standard was predicted to be exceeded. Similar to PM_{10}, these modelled exceedances of the TSP criteria appear to be linked to limited meteorological conditions.

From the above, the Existing Development Scenario potential impacts of dust on human health (PM_{10}) and on visual amenity (TSP) (for BHP Billiton Operations), modelled that:

- The maximum 24-hour average concentration is higher than the assessment criteria at two sensitive receptors, i.e. Tower Hill and Newman.
- Out of the two impacted sensitive receptors, a higher number of excursions are noted at Tower Hill, which is an intermittently occupied receptor.
- The excursions noted at these receptors indicate the potential for existing BHP Billiton Iron Ore operations to impact air quality in the Pilbara region.
- At these two impacted receptors, there is considerable reduction from the predicted 24-hour average maximum PM_{10} and TSP concentrations when the lower 24-hour average percentiles (99th to 90th percentiles) are considered.
- The maximum predicted concentrations could therefore be regarded as a single extreme event that may occur under certain meteorological conditions.

BHP Billiton Iron Ore’s impact to human health and visual amenity from dust from existing development is therefore not considered significant and is being continuously managed through business-as-usual management.

30% Conceptual Development Scenario

PM_{10}

As expected, the highest maximum modelled concentrations occur for the No Control management scenarios, with a reduction in the maximum concentrations noted for the Standard Control management scenarios. The lowest maximum modelled concentrations are observed for the Leading Control management scenarios. Although the No Control management scenarios are discussed below, they should not be considered representative of the likely impacts, as BHP Billiton Iron Ore has historically operated with standard dust controls in place and will continue to do so in the future. These data are only presented to emphasise the effectiveness and importance of dust controls measures.

The total number of sensitive receptor locations where models found the Air NEPM standard and Taskforce guideline to be exceeded are summarised in Table 71 and Table 72, respectively. For model runs that included BHP Billiton Iron Ore mining operations, these were further categorised into particulate management control scenarios. Note that the total numbers presented include both temporary and continuous occupancy sites, which overstates the potential significance of the emissions. The tables also present the number of continuous occupancy locations where the assessment criteria are predicted to be exceeded, which provides a more suitable comparison for impact.

Table 71: Total number of sensitive receptor locations where the Air NEPM standard was found to be exceeded – 30% Conceptual Development Scenario

Management control scenario	BHP Billiton Iron Ore mining operations only	Third-party mining operations only	Cumulative assessment
No Control	16 (4 continuous occupancy)	5 (1 continuous occupancy)	18 (5 continuous occupancy)
Standard Control	9 (2 continuous occupancy)		13 (3 continuous occupancy)
Leading Control	2 (no continuous occupancy)		6 (1 continuous occupancy)

Table 72: Total number of sensitive receptor locations where the Taskforce guideline was found to be exceeded – 30% Conceptual Development Scenario

Management control scenario	BHP Billiton Iron Ore mining operations only	Third-party mining operations only	Cumulative assessment
No Control	10 (2 continuous occupancy)	3 (1 continuous occupancy)	13 (3 continuous occupancy)
Standard Control	5 (1 continuous occupancy)		8 (2 continuous occupancy)
Leading Control	Zero		4 (1 continuous occupancy)

By implementing Standard Controls at all BHP Billiton Iron Ore mining operations, the predicted PM_{10} concentrations have been reduced compared to the No Control management scenario. However, there are still cumulatively three (Marillana Homestead, Capricorn Roadhouse and Newman) and two (Marillana Homestead and Newman) continuous occupancy receptors at which the Air NEPM standard and Taskforce guideline, respectively, are predicted not to be achieved. The model predicts the highest number of exceedances will occur at Marillana Homestead, with 112 days above the Air NEPM standard and 88 days above the Taskforce guideline. Hence, the model indicated there is still a high potential for PM_{10} emissions to impact sensitive receptors with Standard Controls in place at all BHP Billiton Iron Ore mining operations.

The application of Leading Controls at BHP Billiton Iron Ore mining operations is predicted to further reduce impacts, with Marillana Homestead being the only continuously occupied sensitive receptor modelled to exceed the PM_{10} criteria (Air NEPM standard or Taskforce guideline). The model predicted there would be 108 days above the Air NEPM standard and 80 days above the Taskforce guideline at this sensitive receptor. Note, however, that the predicted PM_{10} concentrations at Marillana Homestead are significantly impacted by third-party operations. Emissions from third-party operations alone are predicted to result in 107 days above the Air NEPM standard and 78 days above the Taskforce guideline at Marillana Homestead. Although not modelled, if Leading Controls were also applied by third-party operations, it is likely the number of exceedances would reduce at this location.

TSP

Similar to the assessment of PM_{10}, the modelling of TSP presents a significant reduction in the maximum predicted dust concentrations in the Standard Controls and Leading Controls dust management scenarios when compared to the unrealistic No Control scenario.

By implementing Standard Controls at all BHP Billiton Iron Ore and third-party mining operations, the predicted TSP concentrations have been reduced compared to the No Control scenario. However, air quality at receptors near Newman and Mount Robinson, as well as near third-party mines, do not meet the assessment criteria (Kwinana EPP standard). Hence, there may still be a potential impact with Standard Controls in place at all BHP Billiton Iron Ore mines and third-party operations.

With Leading Controls at BHP Billiton Iron Ore mining operations and Standard Controls at the third-party operations, Marillana Homestead was the only permanently occupied sensitive receptor to exceed the Kwinana EPP standard and limit. As with the PM_{10} assessment, the TSP concentrations appear to be strongly influenced by third-party operations, which are outside BHP Billiton Iron Ore's control. BHP Billiton Iron Ore's cumulative contribution to TSP concentrations at Marillana Homestead is low when Leading Controls are applied (Appendix 9).

With Leading Controls, the 99th percentile PM_{10} values for Newman Town Centre were 38µm/m^3, which is below the conservative NEPM target value of 50µm/m^3, and similarly TSP was 58 which is below the conservative Kwinanna EPP target value of 90µm/m^3. The full results are available in Appendix 9.

From the above, the 30% Conceptual Development Scenario modelled impacts (for BHP Billiton Iron Ore impacts) of dust on human health that showed:

- As anticipated, the highest maximum concentrations are noted for the No Control scenario with a reduction in the maximum concentrations noted for the Standard Control scenario. The lowest maximum concentration is observed for the Leading Control scenario. It is worth noting that while BHP Billiton Iron Ore historically operates with Standard Controls, the No Control scenario is presented to emphasise the importance of dust controls.
- There is a significant reduction in the maximum predicted dust concentrations in the Standard Controls and Leading Controls dust management scenarios when compared to the No Control scenario.
- Across the various control scenarios, the top three maximum PM_{10} concentrations (in descending order) were noted at Mount Robinson, Tower Hill, and Weeli Wolli Spring and Outlet, which are all intermittently occupied receptor locations.
- The receptors near Newman (i.e. Mount Newman, Tower Hill, Ophthalmia Dam, Round Hill, Kalgan Pool, Capricorn Roadhouse and Newman) receive the highest predicted TSP concentrations as expected due to increased mining activities in close vicinity. The other receptors at Fig Tree Crossing, Weeli Wolli Spring and Outfall and Mount Robinson are also predicted to receive elevated TSP concentrations.
- The maximum predicted concentrations are single events that could be managed during operations through a dust management procedure.
- The predicted high TSP concentrations at the aforementioned receptors indicate there is a high potential for TSP to impact the Pilbara Region in the unlikely event that dust controls are not applied to operations.

Note that a total of 14 recreational sites, rest stops and lookouts where people congregate only intermittently are treated as sensitive receptors in the model. These receptors have still been assessed against the Kwinana EPP to provide a conservative potential dust impact.

BHP Billiton Iron Ore's impact to human health and visual amenity from dust at the 30% Conceptual Development Scenario shows that, with Leading Controls in place, performance criteria can be met. As BHP Billiton Iron Ore currently uses business-as-usual management practices, Leading Controls have been added to the Air Emissions Management toolkit; and thus, the significance of impact to human health and visual amenity from dust at the 30% Conceptual Development Scenario is considered to meet the EPA objective.

Full Conceptual Development Scenario

PM_{10}

As with the 30% Conceptual Development Scenario, the highest maximum concentrations for the Full Conceptual Development Scenario occurred for the No Control dust management scenario with progressive reductions observed in the maximum concentrations for the Standard and Leading Controls management scenarios. As stated previously, the No Control scenario is presented to emphasise the importance and known effectiveness of dust control measures and is not a realistic or likely scenario.

The total number of sensitive receptor locations where the models found the Air NEPM standard and Taskforce guideline to be exceeded are summarised in Table 73 and Table 74, respectively. The tables also present the number of continuous occupancy locations where assessment criteria are predicted to be exceeded, which provides a suitable comparison against the selected assessment criteria for potential impact.

Table 73: Total number of sensitive receptor locations where the Air NEPM standard was found to be exceeded – Full Conceptual Development Scenario

MANAGEMENT CONTROL SCENARIO	BHP BILLITON IRON ORE MINING OPERATIONS ONLY	THIRD-PARTY MINING OPERATIONS ONLY	CUMULATIVE ASSESSMENT
No Control	22 (9 continuous occupancy)		23 (10 continuous occupancy)
Standard Control	14 (4 continuous occupancy)	5 (1 continuous occupancy)	18 (5 continuous occupancy)
Leading Control	1 (no continuous occupancy)		8 (2 continuous occupancy)

Table 74: Total number of sensitive receptor locations where the Taskforce guideline was found to be exceeded – Full Conceptual Development Scenario

MANAGEMENT CONTROL SCENARIO	BHP BILLITON IRON ORE MINING OPERATIONS ONLY	THIRD-PARTY MINING OPERATIONS ONLY	CUMULATIVE ASSESSMENT
No Control	15 (4 continuous occupancy)		19 (6 continuous occupancy)
Standard Control	6 (2 continuous occupancy)	3 (1 continuous occupancy)	11 (3 continuous occupancy)
Leading Control	Zero		5 (1 continuous occupancy)

As with the 30% Conceptual Development Scenario, there are significant decreases from the maximum predicted PM_{10} concentrations at sensitive receptors towards the lower statistics (99th to 95th percentiles). This indicates that the maximum predicted concentrations are associated with certain climatic conditions that could be managed during operations through a dust management procedure. The modelling shows there would be a high potential for PM_{10} emissions from mining operations to impact sensitive receptors if no management controls were adopted by BHP Billiton Iron Ore; however this is not a realistic scenario.

By implementing Standard Controls at BHP Billiton Iron Ore and third-party mining operations, the predicted PM_{10} concentrations have been reduced compared to the No Control management scenario. However, there are still five and three continuous occupancy receptors that do not achieve the Air NEPM standard and Taskforce guideline, respectively. Hence, there may still be a potential for PM_{10} emissions to impact sensitive receptors with Standard Controls in place at all BHP Billiton Iron Ore mining operations.

The application of Leading Controls at BHP Billiton Iron Ore mining operations and Standard Controls at third-party mining operations is predicted to further reduce impacts, with Marillana Homestead and Wirrilimarra community area being the only continuously occupied sensitive receptors modelled to exceed the Air NEPM standard (Marillana Homestead is the only continuously occupied sensitive receptor predicted to exceed the Taskforce guideline). It is worth noting the predicted PM_{10} concentrations at Marillana Homestead and Wirrilimarra community area in the Leading Controls dust management scenario are primarily impacted by third-party operations, with BHP Billiton Iron Ore's operations only having a minor, but cumulative impact. For example, the modelling predicts there will be 113 exceedances of the Air NEPM standard given cumulative emissions, whereas given third-party emissions only still results in 107 exceedances being predicted. This and the 30% Conceptual Development Scenario highlight the potential significance of third-party operations. It also highlights that, with Leading Control management measures, BHP Billiton Iron Ore mining operations are predicted to have a significantly reduced impact on sensitive receptors. It is unlikely Leading Controls measures will be required at all of BHP Billiton Iron Ore mining operations in the future, and the need for such controls will be considered on a case-by-case basis as operations are planned, constructed and operated.

TSP

As with the 30% Conceptual Development Scenario and the Full Conceptual Development Scenario for PM_{10}, the modelling presents a significant reduction in the maximum predicted dust concentrations in the Standard Controls and Leading Controls dust management scenarios when compared to the unrealistic No Control scenario.

By implementing Standard Controls at all BHP Billiton Iron Ore and third-party mining operation, the predicted TSP concentrations have been reduced compared to the No Control scenario. However, receptors near Marillana Homestead, Tower Hill and Eagle Rock Hole do not meet the assessment criteria (Kwinana EPP limit), so there may still be a potential impact for the central Pilbara region with Standard Controls in place.

With Leading Controls at BHP Billiton Iron Ore mining operations and Standard Controls at the third-party operations, the predicted TSP concentrations at Marillana Homestead still cannot meet the assessment criteria (Kwinana EPP limit). However, implementing these dust management scenarios results in considerable reductions in TSP concentrations compared to the No Control scenario. This sensitive receptor is shown to be influenced most significantly by third-party mining operations, with only minor cumulative impacts by BHP Billiton Iron Ore mining operation with Leading Controls.

From the above, it is worth noting that the Full Conceptual Development Scenario modelled is highly precautionary as the assumption is that all mines have been developed and are operating simultaneously. Therefore, this scenario is unlikely to occur. The Full Conceptual Development Scenario impacts (for BHP Billiton Iron Ore impacts) of dust on human health and visual amenity modelled that:

- For the No Control, Standard Controls and Leading Controls scenarios, there were 22 (receptor types included homesteads, lookouts, recreational sites, rest stop, roadhouse, town centre, town site and Aboriginal community), 14 (receptor types included homesteads, lookouts, recreational sites, rest stop, roadhouse, and town centre) and 1 (receptor site was a lookout) occasions that had PM_{10} concentrations in excess of 50 $\mu g/m^3$.
- For the No Control and Standard Controls scenarios, there were 15 (receptor types included homesteads, lookouts, recreational sites, rest stop, roadhouse and town centre) and six (receptor types include lookouts, recreational sites, rest stop, roadhouse, and town centre)

that had PM_{10} concentration in excess of 70 µg/m^3. There were no exceedances of the Taskforce guideline (70µg/m^3) for the Leading Controls scenario.

- In summary, the Leading Controls have greatly reduced the potential impact to the sensitive receptors compared to the No Control and Standard Controls scenarios.
- With Leading Controls in place, there are considerable reductions of TSP concentrations compared to the No Control scenario. However, the predicted TSP concentrations at Tower Hill exceed the Kwinana EPP standard but comply with the Kwinana EPP limit.
- The maximum predicted concentrations are single events that could be managed during operations through a dust management procedure.

Dust modelling undertaken for this PERSP shows that PM_{10} and TSP levels could potentially be exceeded at the Marillana Homestead and Wirrilimarra community area sensitive receptors under various development and dust management scenarios. These receptors are primarily impacted by third-party operations, with BHP Billiton Iron Ore's operations only having a minor but cumulative impact.

This assessment has clearly demonstrated the improvement possible with management intervention. Furthermore, the Strategic Proposal assessment has considered controls in the broad sense, and it is reasonable to assume that, as a regional management approach is applied to Derived Proposals, there will be greater opportunity to implement tailored actions to manage emissions effectively.

The assessment completed for the Strategic Proposal shows that, with the implementation of management measures, the EPA objective for air quality can be met. BHP Billiton Iron Ore will implement a combination of targeted management and controls, in addition to business-as-usual management, as required to manage air quality to an acceptable level.

This assessment has demonstrated the improvement possible with mitigation of dust impacts on the broader Newman area. Furthermore, the Strategic Proposal assessment has considered controls in the broad sense; and it is reasonable to assume that, as a regional management approach is applied to Derived Proposals, there will be greater opportunity to implement tailored actions to manage emissions effectively.

8.4.3 GREENHOUSE GAS ASSESSMENT

8.4.3.1 EXISTING ENVIRONMENT

The GHGs quantified for the Strategic Proposal were carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). As the effects of GHGs are assessed at a global scale, the use of dispersion modelling does not provide useful analysis. GHG emissions were therefore considered in terms of total emissions produced, applying an emission estimation technique consistent with the National Greenhouse and Energy Reporting (NGER) System requirements (DCC 2008; DCCEE 2014 and DCCEE, 2009).

Unlike air quality criteria, there are no specific ambient GHG criteria. Instead, the NGER framework requires the reporting of 'direct GHG emissions' (Scope 1) and 'indirect GHG emissions due to energy product use' (Scope 2). Both of these emissions have been considered within this section.

8.4.3.2 POTENTIAL IMPACTS

GHG emissions are associated with climate change, which has the potential to have widespread impacts on human and natural systems (IPCC 2014) . Climate change is expected to have significant impacts in Western Australia in the form of temperature and sea level rises, increased fire frequency, more intense extreme events and changed rainfall patterns (EPA 2015e). The EPA remains concerned about the emission of GHGs and believes that proponents should continue to maintain their focus on best practice design, technology and operations to ensure emissions are minimised as far as practicable (EPA 2015e).

Climate change is discussed further in Section 5.7.1.

8.4.3.3 MITIGATION

Air quality will be managed through the implementation of the Air Quality Management toolkit (Figure 63) and through development of a regional approach to management. Specific to GHGs, BHP Billiton Iron Ore routinely identifies, evaluates and implements GHG reduction initiatives to find operational efficiencies and improvements so that GHG emissions per tonne of material moved decreases. BHP Billiton Iron Ore will continue to implement GHG reduction initiatives during implementation of the Strategic Proposal.

8.4.3.4 SIGNIFICANCE OF IMPACTS

Applying a significance framework as set out in Environmental Assessment Guideline No.9, the EPA may decide to assess GHG emissions within the EIA process if a proposal's expected total GHG emissions are deemed to be significant (EPA 2015e). The EPA defines this as proposals that have the potential to significantly increase the state's GHG emissions, which totalled 70.5 Mt of CO2-e in 2011-12 (EPA 2015e). Comparison against state and Australian levels were used for the basis of significance of impact.

Information on GHG emissions (by fuel type) for the following existing mining operations was analysed: Mining Area C, Yandi, Orebody 23 to 25, Orebody 18 and Mt Whaleback mine. The data on fuel usage, together with the tonnage of material moved, was used to generate a weighted average fuel use per tonne of material moved. This was used to calculate the GHG emissions for the three development scenarios, i.e. Existing Development Scenario, 30% Conceptual Development Scenario and Full Conceptual Development Scenario.

The GHG emissions were calculated using an average fuel use per tonne of material moved for existing BHP Billiton Iron Ore operations. This weighted average combined with the tonnage of material moved for future operations was used to calculate the GHG emissions.

The total GHG emissions from BHP Billiton Iron Ore operations in the central Pilbara region for the three scenarios are presented in Table 75. The total GHG emissions from the Existing Development Scenario, 30% Conceptual Development Scenario and Full Conceptual Development Scenario are 0.9, 2.6 and 4.4 Mt CO_2-e per annum respectively (Appendix 9).

For context,

Table 76 provides predicted GHG emissions for 2011-12 at an Australian and Western Australian scale (DCCEE 2014).

Table 75: Predicted GHG emissions from BHP Billiton Iron Ore operations

Emission	Existing Development Scenario	30% Conceptual Development Scenario	Full Conceptual Development Scenario
	($Mt CO_2$-e/annum)		
Scope 1	0.6	1.8	3.0
Scope 2	0.3	0.8	1.4
Total	0.9	2.6	4.4

Table 76: Predicted GHG emissions (2011-12) for Australia and Western Australia

GEOGRAPHIC COVERAGE	SOURCE COVERAGE	TIMESCALE	EMISSIONS (MT CO_2-E/ANNUM)	DESCRIPTION
Australia	Total Scope 1 and Scope 2 emissions	2011-12	554.6	Including Land Use, Land Use Change and Forestry (LULUCF)
			543.6	Excluding LULUCF
Western Australia	Total Scope 1 and Scope 2 emissions	2011-12	75.9	Including LULUCF
			70.5	Excluding LULUCF

Source: DCCEE (2014).

The predicted total GHG emissions calculated for BHP Billiton Iron Ore's existing mining operations in the central Pilbara account for 0.2% and 1.2% of the Australian and Western Australian 2011-12 total emissions, respectively (Table 77). Without estimating the potential change in the national and state estimated GHG emissions over the life of the Strategic Proposal (BHP Billiton Iron Ore's Full Conceptual Development Scenario), BHP Billiton Iron Ore's contribution is predicted to increase to 0.8% of the national level and 6.2% of the Western Australian level, respectively. The GHG intensity is comparable with similar developments.

Table 77: GHG emissions contributions from BHP Billiton Iron Ore operations

TEMPORAL SCENARIO	AUSTRALIAN GHG EMISSIONS INCLUDING LULUCF	AUSTRALIAN GHG EMISSIONS EXCLUDING LULUCF	WESTERN AUSTRALIAN GHG EMISSIONS INCLUDING LULUCF	WESTERN AUSTRALIAN GHG EMISSIONS EXCLUDING LULUCF
Existing	0.2%	0.2%	1.2%	1.3%
30% Conceptual Development Scenario	0.5%	0.5%	3.4%	3.7%
Full Conceptual Development Scenario	0.8%	0.8%	5.8%	6.2%

BHP Billiton Iron Ore considers that GHG emissions can be managed to an acceptable level, given that the predicted GHG emissions for the Strategic Proposal under the Full Conceptual Development Scenario is 6.2% of current state levels. Furthermore, BHP Billiton Iron Ore's application of the Air Emissions Management Toolkit (Figure 63), will ensure that improvements in GHG emissions will continue into the future.

8.4.4 SUMMARY OF ASSESSMENT OUTCOMES

The EPA's determination on the ESD (BHP Billiton Iron Ore 2013) was that air quality was a preliminary environmental factor. The EPA identified cumulative and regional-scale impacts to air quality as a potential outcome of the Strategic Proposal if not assessed and managed appropriately. Although air quality was not identified as a key environmental factor for the Strategic Proposal, BHP Billiton Iron Ore commissioned the development of an air quality model for the region and completed a cumulative impact assessment to ensure a thorough assessment was completed for this factor.

Where model predictions exceed the relevant assessment criteria, it suggests that, without appropriate management controls, the proposed development may have a high potential to increase PM_{10} concentration at the nearby sensitive receptors. The cumulative modelling results for existing mining operations predict exceedances at one continuously occupied sensitive receptor location (Newman). For the 30% Conceptual Development Scenario, applying the Standard Controls for BHP Billiton Iron Ore operations may not adequately minimise the cumulative PM_{10} concentrations at sensitive receptor locations. With the Leading Controls in place, the results show the cumulative 24-hour PM_{10} concentrations at one continuously occupied sensitive receptor (Marillana Homestead) are predicted to be above the Air NEPM-based assessment standard. Note the predicted PM_{10} concentrations at Marillana Homestead in this scenario are primarily attributable to third-party operations, with BHP Billiton Iron Ore's operations only having a very minor but cumulative impact.

Similarly, for the Full Conceptual Development Scenario, with Leading Controls in place, the results show the cumulative 24-hour PM_{10} concentrations at two continuously occupied sensitive receptors (Marillana Homestead and Wirrilimarra community area) are predicted to be above the Air NEPM-based assessment standard. This represents a significant reduction in the maximum cumulative PM_{10} concentrations in the Standard Controls and Leading Controls dust management scenarios when compared to the No Control scenario. Again, the exceedances are primarily associated with third-party operations at these sensitive receptors, with BHP Billiton Iron Ore contributing to the cumulative impacts only.

As with PM_{10}, in instances where modelled TSP predictions exceed the relevant assessment criteria, this suggests that, without mitigating controls in place, the proposed development may have the potential to increase particulate concentrations at nearby sensitive receptors. The modelling results for existing mining operations show the predicted TSP level at one continuously occupied sensitive receptor location (Newman) is predicted to be higher than the assessment criteria based on the Kwinana EPP standard and Kwinana EPP limit. For the 30% Conceptual Development Scenario, applying the Standard Controls may not be adequate to minimise the cumulative TSP emissions. With the Leading Controls in place, the results show that the cumulative 24-hour TSP concentration at one continuously occupied sensitive receptor location (Marillana Homestead) is predicted to be above the Kwinana EPP standard. However, there are considerable reductions in TSP concentrations compared to the No Control management scenario. This sensitive receptor is shown to be influenced most significantly by third-party mining operations, with only minor cumulative impacts by BHP Billiton Iron Ore mining operation with Leading Controls.

This assessment has demonstrated the improvement possible with mitigation of dust impacts on the broader Newman area. Furthermore, the Strategic Proposal assessment has considered controls in the broad sense; and it is reasonable to assume that, as a regional management approach is applied to Derived Proposals, there will be greater opportunity to implement tailored actions to manage emissions effectively.

The management of particulate emissions is an important operational focus for BHP Billiton Iron Ore. The Company has invested substantial effort to and continues to play an important role in the investigation and management of air quality across the Pilbara region. The company's 2013/14 Annual Environment Report (BHP Billiton Iron Ore 2014a) provides examples of management strategies being implemented and the positive outcomes of these actions. BHP Billiton Iron Ore will continue to build on these actions and knowledge to manage potential air quality impacts associated with future mining operations. BHP Billiton Iron Ore implements standard particulate control measures as part of its current operations. It is recognised that, in the future, in some circumstances Standard Controls will not be sufficient and additional emission measures may be required as cumulative air emissions increase.

The GHG assessment was carried out for the Full Conceptual Development Scenario, including current third party operations. This conceptual and most conservative scenario accounted for 0.8% of the national GHG level (including Land Use, Land Use Change and Forestry (LULUCF)) and 6.2% of Western Australia levels (including LULUCF) and 0.8% of national levels. With ongoing improvements to technology and the way in which BHP Billiton Iron Ore operates, the Company is confident that emissions will reduce over time. The GHG model is conservative in that all modelled operations will not be active at the same time, and as such the GHG emissions are expected to be less than modelled. The modelled and anticipated GHG emissions are not expected to be significant.

The assessment completed for the Strategic Proposal shows that, with the implementation of management measures, the EPA objective for air quality can be met. BHP Billiton Iron Ore will implement a combination of targeted management and controls, in addition to business-as-usual management, as required to manage air quality and GHG emissions to an acceptable level.

8.5 Integrating Factors

The EPA's determination as part of the Strategic Proposal referral and as outlined in the ESD (BHP Billiton Iron Ore 2013) was that Rehabilitation and Decommissioning and Offsets were key preliminary environmental factors within the Integrating Factors theme.

Rehabilitation and Decommissioning (closure) includes the forward planning and execution of activities related to closing a mine, rehabilitation of the land and decommissioning or transfer of infrastructure (including rail) when operations have ceased. The field of rehabilitation and decommissioning is multidisciplinary, drawing on the strategies, procedures and processes of many technical specialties, including, but not limited to, biodiversity, heritage, water and mine planning. Balancing the expectations of key stakeholders and optimising business value (i.e. cost, reputation, risk and liability) in decision-making is a focus for closure and rehabilitation within the broader consideration of the surrounding social and environmental values.

The EPA (EPA 2014b) defines environmental offsets as:

> …actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a project or activity. Unlike mitigation actions which occur on-site as part of the project and reduce the direct impact of that project, offsets are undertaken outside of the project area and counterbalance significant residual impacts.

Contemporary environmental offset guidance in Australia at both the state and Commonwealth level focuses, in the main, on individual project offsets. BHP Billiton Iron Ore recognises that a more strategic focus to offsets can potentially deliver greater environmental outcomes over a larger area and longer time frame than would otherwise be the case.

8.5.1 INTRODUCTION

8.5.1.1 ENVIRONMENTAL FACTOR OBJECTIVES

The EPA applies environmental objectives to the assessment of proposals. BHP Billiton's contribution to achieving these factors is summarised in

Table 78. As Integrating Factors, by their nature, amalgamate the consideration of other factors, the objectives for Land, Water, People and Air are also applicable. The Guiding Principles provide further clarity as to the standards that are considered by BHP Billiton Iron Ore in meeting the outcome-based objective for rehabilitation and decommissioning.

Table 78: EPA and BHP Billiton Iron Ore factor objectives for Integrating Factor

FACTOR	EPA OBJECTIVE (EPA 2015A)	BHP BILLITON IRON ORE OBJECTIVE[1]
Rehabilitation and Decommissioning	To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.	BHP Billiton Iron Ore shall manage its activities for the creation of safe, stable, non-polluting and sustainable landscapes so as to reduce risks to an acceptable level.
Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.	BHP Billiton Iron Ore shall counterbalance any significant residual environmental impacts or uncertainty through the application of appropriate, effective and enduring offsets.

1. 'Acceptable level' is defined as per the EPA's significance framework in Environmental Assessment Guideline 9 (EPA 2015b); thus BHP Billiton Iron Ore considers an 'acceptable level' of impact to be a level of residual impact that meets the EPA's objectives for that environmental factor.

8.5.1.2 REHABILITATION AND DECOMMISSIONING GUIDING PRINCIPLES

Described below are a set of fundamental, enduring principles that guide how BHP Billiton Iron Ore considers rehabilitation and decommissioning across its operations to achieve the BHP Billiton Iron Ore objective:

- Informed planning and design: rehabilitation and decommissioning requirements are considered at a mine deposit and regional scale, upfront and integrated into mine plans to achieve optimal business value and a sustainable final land use;
- Sustainable final land use: Final land use and rehabilitated areas meet stakeholder expectations and consider the following:
  - local land management practices;
  - ongoing management requirements (e.g. roads and tracks);
  - Closure landform integration, including visual impacts, landform stability (physical and geochemical) and hydrological regimes;
  - local baseline conditions (e.g. flora, vegetation, fauna and fauna habitat);
  - ecosystem resilience in terms of flora, vegetation, fauna, and surface and groundwater hydrology;
  - Infrastructure transfer or decommissioning;
  - management or remediation of contaminated sites; and
  - amenity.
- Prioritise health and safety: All mine rehabilitation and decommissioning is planned so that the risks to health and safety of people within BHP Billiton Iron Ore's area of influence are minimised. Unauthorised public access risk will be managed through the implementation of controls in accordance with regulatory requirements and consideration of industry guidance;
- Effective stakeholder engagement: Transparent and proactive stakeholder engagement occurs for all planned activities that may impact surrounding communities, including consideration of communities impacted by closure; and
- Adaptive management: BHP Billiton Iron Ore's management approach is constantly evaluated and, where required, progressively improved to ensure the desired environmental outcomes are effectively achieved over the life of BHP Billiton Iron Ore's operations (see Section 12.1.1).

8.5.1.3 KEY LEGISLATION AND GUIDANCE

As discussed in Section 7.1, BHP Billiton Iron Ore has addressed applicable legislation, policy and guidance for each factor. These are detailed in Appendix 1, Table 1.5. Additional materials, relevant to Rehabilitation and Decommissioning will be considered at Derived Proposal stage as required, including, but not limited to, DMP Environmental Notes (for example Acid Mine Drainage, 2009 and Waste Rock Dumps 2009).

BHP Billiton Iron Ore's activities will be managed in accordance with all relevant legislation, policy and guidance. Where there is any conflict between the closure plans and statutory requirements, the statutory requirements will take precedence.

8.5.1.4 REHABILITATION AND DECOMMISSIONING MANAGEMENT TOOLKIT

BHP Billiton Iron Ore's management toolkit for Rehabilitation and Decommissioning is presented in Figure 70. The measures presented are not exhaustive, and additional management measures developed over the life of BHP Billiton Iron Ore's operations will be assessed and applied on a merit-based approach.

Rehabilitation and decommissioning are multi-disciplinary activities; thus, the Land and Biodiversity Management toolkit, Water Management toolkit, Air Emissions Management toolkit and the factor-based toolkits for the Heritage Management toolkit and Amenity Management toolkit – will also be utilised when managing rehabilitation and decommissioning activities. Rehabilitation and Decommissioning Toolkit also includes provisions for offsets, where significant residual impact after rehabilitation and decommissioning in predicted to occur. Offsets are discussed in Section 8.5.3.

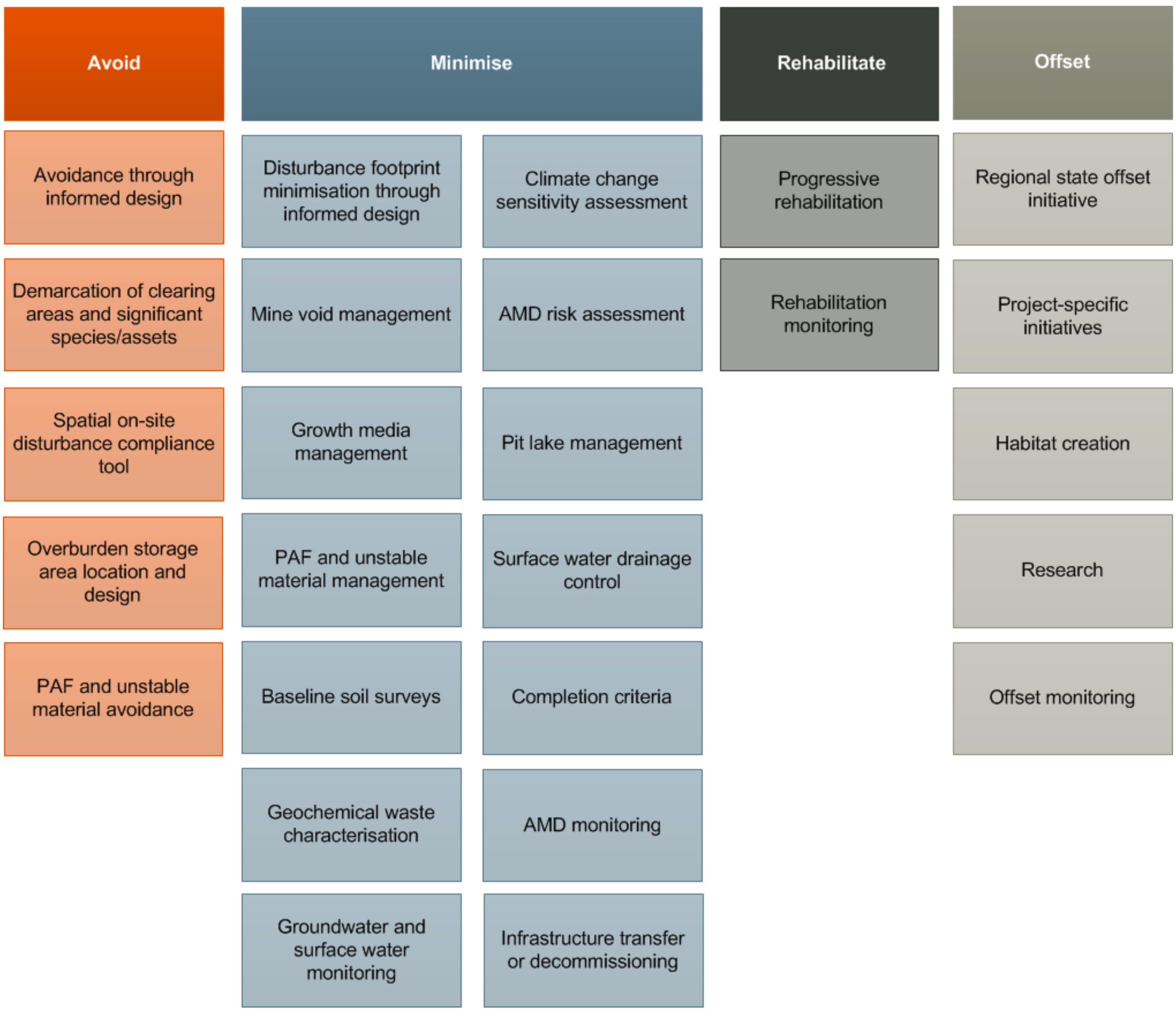


Figure 70: BHP Billiton Iron Ore's Rehabilitation and Decommissioning Management toolkit

8.5.2 REHABILITATION AND DECOMMISIONING

BHP Billiton Iron Ore's closure plans for operations within the Pilbara will be consistent with the DMP and EPA (2015c) mine closure guidelines. Closure plans are used by BHP Billiton Iron Ore and its contractors in the implementation of appropriate rehabilitation and mine closure strategies. The closure plans are revised at intervals consistent with DMP and EPA guidelines and are based on BHP Billiton Iron Ore's strategic approach to closure planning across its Pilbara assets.

8.5.2.1 POTENTIAL IMPACTS

The typical activities associated with iron ore mining in the Pilbara that are relevant to typical rehabilitation and decommissioning activities, are listed in Table 79. A brief description of each potential impact is provided.

Table 79: BHP Billiton Iron Ore's activities and their potential impacts associated with rehabilitation and decommissioning.

SOURCE OF POTENTIAL IMPACT	DESCRIPTION OF POTENTIAL IMPACT (DIRECT AND INDIRECT) APPLICABLE TO BHP BILLITON IRON ORE ACTIVITIES
Permanent modification of landforms	The construction and operation of open-cut mines and the associated infrastructure can result in the permanent modification of landforms, for example, the removal of a ridgeline, the creation of mine voids, or the addition of an overburden storage area. These modifications may have adverse impacts on environmental values (e.g. removal of habitat) or social values (e.g. impact to visual amenity) or may create a public safety* risk upon closure). Landforms are discussed in Section 8.1.6.
Impacts to hydrological processes	Open-cut mining in the Pilbara has the potential to impact the hydrological (surface water) and hydrogeological (groundwater resources) regime at closure through the following avenues: • altered surface water availability; • change in surface water quality; • establishment of pit lakes with degraded pit lake water quality; • reduction in groundwater availability; and • change in groundwater quality (e.g. salinity); Impacts associated with AMD are discussed in Section 8.1.6.2.
Permanent modification of vegetation and habitat	Some landforms will be modified extensively from their original state, as will the vegetation and habitats that those landforms support; therefore, rehabilitation of vegetation and habitats may not be able to achieve outcomes that represent predisturbance or reference site conditions. As at 30 June 2014, the net disturbance across BHP Billiton Iron Ore's operations for activities associated with mining was 19,037 ha, with 2,569 ha having been rehabilitated (BHP Billiton Iron Ore 2014a).
Contamination of soils and water	Soil and water contamination impacts within the context of mine closure and rehabilitation can include: • increased turbidity in surface water due to surface erosion of final landforms; • acidification of surface water bodies (natural or artificial) due to exposure and subsequent leaching of sulfide-bearing minerals (acid mine drainage); • exposure of fibrous material included in mine wastes; • contamination of surface water bodies from airborne particulates; and • residual site contamination from operations as they relate to the *Contaminated Sites Act 2003*, generally including management of hydrocarbons and hazardous materials (such as explosives).

*Ineffective closure and rehabilitation of a mine or its associated infrastructure has the potential to represent a safety risk to the general public. Residual post-closure landforms that may result in increased public safety risk through unauthorised access include mine voids, pit lakes, mine benches, steep high wall faces and tailing storage facilities. Providing detailed public safety measures is outside the scope of the PERSP, is covered under separate legislative frameworks (e.g. *Mines Safety and Inspection Act 1994* and *Occupational Safety and Health Act 1984*), and is therefore not discussed further.

BHP Billiton Iron Ore assesses compliance with the completion criteria via the use of monitoring tools, including visual stability and initial establishment inspections on OSAs (rehabilitation establishment assessment), rehabilitation development monitoring, rehabilitation landform appraisal, and water quality monitoring for ground and surface water. Specific post-closure and rehabilitation monitoring plans are developed that include both a spatial and temporal component.

The establishment of completion criteria for rehabilitation considers the early development of ecological completion criteria metrics for both low-impact (e.g. borrow pits; infrastructure areas) and high-impact (e.g. OSAs) rehabilitation areas. BHP Billiton Iron Ore will use its understanding from the findings of ongoing research and development programs including landform trials, improved knowledge of the ecosystem development derived from rehabilitation monitoring programs and greening initiatives to inform the assigning completion criteria.

Progressive rehabilitation and monitoring provide early opportunities to test management measures and inform progress towards agreed completion objectives and criteria. The closure and rehabilitation objectives will be based on the agreed final land uses applicable to the particular area. It is recognised that the land is altered fundamentally from its pre-existing condition. Completion criteria are designed to allow the confirmation that agreed objectives have been met, providing both BHP Billiton Iron Ore and the regulator with clear direction for the planning, establishment and management of mine rehabilitation at the site.

Rehabilitation success depends on a number of factors, including footprint type and time from activity cessation (Table 80). From this, it is accepted that mine pit voids cannot be rehabilitated above Degraded vegetation condition; but based on BHP Billiton Iron Ore's experience in the Pilbara, the Company believes that other types of disturbance can be successfully rehabilitated to at least Good vegetation condition.

Table 80: Rehabilitation stages and vegetation condition rating

		OSA			Rail			Mine Pit			Associated Infrastructure		
Rehab. Stage	Activities on the Ground	Cumulative time from mine cessation (years)	Age of Rehab. (years)	Vegetation Condition	Cumulative time from mine cessation (years)	Age of Rehab. (years)	Vegetation Condition	Cumulative time from mine cessation (years)	Age of Rehab. (years)	Vegetation Condition	Cumulative time from mine cessation (years)	Age of Rehab. (years)	Vegetation Condition
Planning and Rehabilitation Operations	Stages from premining (planning) through mining; activities include growth media management, seed management, and rehabilitation earthworks to standard.	1	0	Completely Degraded	3	0	Completely Degraded	1	0	Completely Degraded	1	0	Completely Degraded
Early Establishment	Developing ecosystem; time to completion is rainfall-dependent. Monitoring undertaken; and where identified and as required, maintenance works completed.	3	2	Degraded	5	2	Degraded	3	2	Completely Degraded	5	4	Good
Maturing Rehabilitation	Maturing ecosystem, monitoring is undertaken, no maintenance should be required.	10	9	Good	12	9	Good	10	9	Degraded	10	9	Very Good
Closure	Agreed final land use values met.	16	15	Very Good	15	12	Very Good	16	15	Degraded	13	12	Very Good

The BHP Billiton Iron Ore footprint from the Strategic Proposal, under the Full Conceptual Development Scenario (minus existing impacts), is 106,473 ha. The proportion of this footprint attributable to the main infrastructure types is shown in Table 81. It should be noted that these areas are conceptual only, and disturbance areas will be verified at the Derived Proposal stage.

Table 81: Potential BHP Billiton Iron Ore footprint for the Strategic Proposal under the Full Conceptual Development Scenario (minus existing impacts), based on infrastructure type

INFRASTRUCTURE TYPE	FOOTPRINT (HA)	PROPORTION OF TOTAL FOOTPRINT (%)
OSA	33,536	31.5%
Associated Infrastructure	15,750	14.8%
Rail	5,194	4.9%
Pit	50,316	47.3%
Other	1,677	1.5%
TOTAL	106,473	100%

As detailed in Table 82, rehabilitation of OSAs, associated infrastructure and rail is anticipated to reach a Good vegetation condition or better once rehabilitated. The Rehabilitation and Decommissioning Management toolkit will be applied to minimise the footprint, where practicable, and to adopt the most effective rehabilitation method available for the infrastructure type at the time.

Mine voids are considered unlikely to achieve a better vegetation condition than Degraded; therefore, BHP Billiton's residual impact, once rehabilitation and decommissioning are complete, is conceptually 50,316 ha[9]. With adaptive management and advances in knowledge, mine void rehabilitation success may improve in the future. BHP Billiton Iron Ore will quantify the footprint area subject to residual impact at the time of any Derived Proposal referral.

8.5.2.2 MITIGATION

Key rehabilitation and decommissioning considerations and application of the mitigation toolkit are summarised in Table 82.

Table 82: Potential management approaches for rehabilitation and decommissioning

SOURCE OF POTENTIAL IMPACT	BHP BILLITON IRON ORE MANAGEMENT APPROACH EXAMPLES[1]
Permanent modification of landforms	• Minimisation of mine voids and pit lakes through mine planning, closure planning and *informed design*. • Implement appropriate *OSA location and design*. • Develop appropriate *completion criteria* for landforms. • Conduct *climate change sensitivity assessment* where appropriate to ensure that final landforms are designed to withstand climate change. • Minimisation of impacts from clearing by *growth media management*, to allow rehabilitation at closure.
Impacts to hydrological processes	• Minimisation of mine voids and pit lakes through mine planning, closure planning and *informed design*.

[9] This is based on the Full Conceptual Development Scenario, which is conservative as it contains developments such as South Flank, which will be referred separately to the Strategic Proposal.

Source of potential impact	**BHP Billiton Iron Ore Management Approach Examples**[1]
	• Minimisation of impacts to water by *surface water drainage control* and through *pit lake management.* Refer to the Water Management Toolkit (Figure 42) for further management measures.
Permanent modification of vegetation and habitat	• *Minimisation of disturbance footprint through informed design*. • Minimisation of impacts from clearing by *growth media management*, to allow rehabilitation at closure. • Avoid ecologically significant areas with strategic *OSA location and design*. • Utilise opportunities for *habitat creation* where possible. • Undertake *progressive rehabilitation* where possible, and *rehabilitation monitoring* to determine rehabilitation success. Refer to the Land and Biodiversity Management Toolkit (Figure 17) for further management measures.
Contamination of soils and water	• Undertake *geochemical waste characterisation* to inform final landform design. • Minimisation of impacts to soils and water through *AMD risk assessment*, and *PAF and unstable material avoidance* and/or *management*.

1. Management approaches are regularly updated as part of BHP Billiton Iron Ore's adaptive management approach.

The most effective mitigation of environmental impacts from mining-associated activities is in planning for closure or cessation of the activities. The successful planning and execution of sustainable closure and rehabilitation in the Pilbara will involve a holistic, long-term view of landscape-scale outcomes coupled with progressive operational-level activities that implement or preserve options that will achieve the desired outcomes. A key driver for the holistic regional approach to closure and rehabilitation is the regional scale and long life span of BHP Billiton Iron Ore's proposed future mining footprint within the Pilbara. This driver necessitates the use of a regional approach adaptable over time, as opposed to considering individual mines in isolation. The regional approach, by its very nature, provides an avenue to consider potential post-closure cumulative impacts, including visual amenity, water, land use, biodiversity and ecosystem function.

BHP Billiton Iron Ore's project development process defines the performance requirements for the initiation, development, execution, close out and transition to operations phases of major capital projects. It sets out the minimum study requirements for each of these phases, including studies specifically related to closure and rehabilitation planning. This process provides the mechanism by which the closure and rehabilitation planning adaptive management commences for a Derived Proposal.

Prior to development, a planning process is used to define mine plan information. Key characteristics are identified that are expected to influence the range of possible closure outcomes and impact assessments. For example, proportion of mine below water table, surface and groundwater hydrological regime, ore and waste volumes and characteristics (geochemical and physical), and proximity to key assets.

Technical assessments, modelling and analyses are undertaken based on the mine plan and key characteristics to determine the range of possible closure outcomes and impact scenarios. Through a formal risk assessment process, the risk level or rating is evaluated, using an appropriate method to then inform the possible management options available to mitigate the post-closure risk. The range of closure outcomes, impacts and management controls are consolidated and assessed internally to determine the business's agreed closure strategy or direction, including the development of deeper technical knowledge where required to reduce uncertainty. The closure strategy is then included in stakeholder consultation and regulatory approval submissions forming the basis for mine closure plans.

Successful implementation of the mine plan to minimise the closure liability requires activity to occur both progressively (during operations) and at closure. Monitoring, auditing and compliance reporting against the closure strategy and more detailed executable rehabilitation plans and completion criteria are progressively undertaken. Post-closure (following completion of closure and rehabilitation works) monitoring against completion criteria will be undertaken, working towards the agreed divestment strategy; and, if required, minor maintenance will occur.

Data acquired over the life of the mine (groundwater characteristics, resource and waste knowledge, land use demands, geotechnical risk and market conditions) are reassessed and used to validate earlier assumptions to ensure the closure and rehabilitation strategy remains consistent with the closure objectives and key considerations, so as to manage any post-closure impact.

A mine closure plan will be prepared, as required, for each Derived Proposal and will provide completion criteria and closure options, if applicable, for the Derived Proposal supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. Throughout the operations phase, iterations of the mine closure plan will progressively refine the closure options with available data, enabling detailed designs and completion criteria to be developed and progressive rehabilitation works to occur. As mining draws to a close, the detailed closure designs will be executed, and the site will move into the post-closure period of monitoring, reporting, completion and sign off. In all cases, the focus for the application of the relevant controls is on achieving the defined completion criteria and following the mitigation hierarchy of control.

8.5.2.3 CASE STUDIES

BHP Billiton Iron Ore will apply mitigation measures from the Rehabilitation and Decommissioning Management toolkit provided in Figure 70 to ensure it achieves its closure and rehabilitation objectives. This section presents several case studies addressing BHP Billiton Iron Ore's approach to the following rehabilitation and decommissioning topics:

- Case Study 10: rehabilitation trials;
- Case Study 11: acid mine drainage;
- Case Study 12: below the water table mining;
- Case Study 13: overburden storage areas; and
- Case Study 14: post-mining land use.

BHP Billiton Iron Ore has over 30 years' experience developing, implementing and adapting its approaches to rehabilitation and decommissioning. A chronology of this experience is provided in Table 83.

Case Study 10: Rehabilitation trials

Rehabilitation trials commenced at Mt Whaleback mine in 1974. By 1977, it was recognised there were difficulties with achieving consistent establishment of spinifex (*Triodia* species) in the rehabilitation areas. Rehabilitation monitoring reviews undertaken in 1997 suggested the key distinction between the undisturbed environment and the rehabilitated areas was spinifex establishment. In 2008, a partnership with the Botanic Gardens and Parks Authority (BGPA) saw the initiation of the Pilbara Seed Atlas. Since 2010, the Pilbara Seed Atlas has provided guidance to site seed management practices with a focus on seed ecology, species identification, scheduling seed collection, storage and germination.

Source: BHP Billiton Iron Ore.
Yarrie site preparation for earthworks (reprofiling) alongside established rehabilitation from the two years previous

One of many specific outcomes from the Pilbara Seed Atlas was emphasising the importance of correct storage conditions for seed viability. To address this, the first controlled-environment seed store at BHP Billiton Iron Ore was purchased in 2011 with a second in 2014. The temperature and relative humidity condition of the seed stores is set on advice from BGPA that is based on years of research. Following the introduction of internal seed storage standards, BHP has also worked collaboratively with commercial seed suppliers to ensure that correct post-harvest storage conditions are similarly applied at off-site seed stores to increase the long-term viability of the seed.

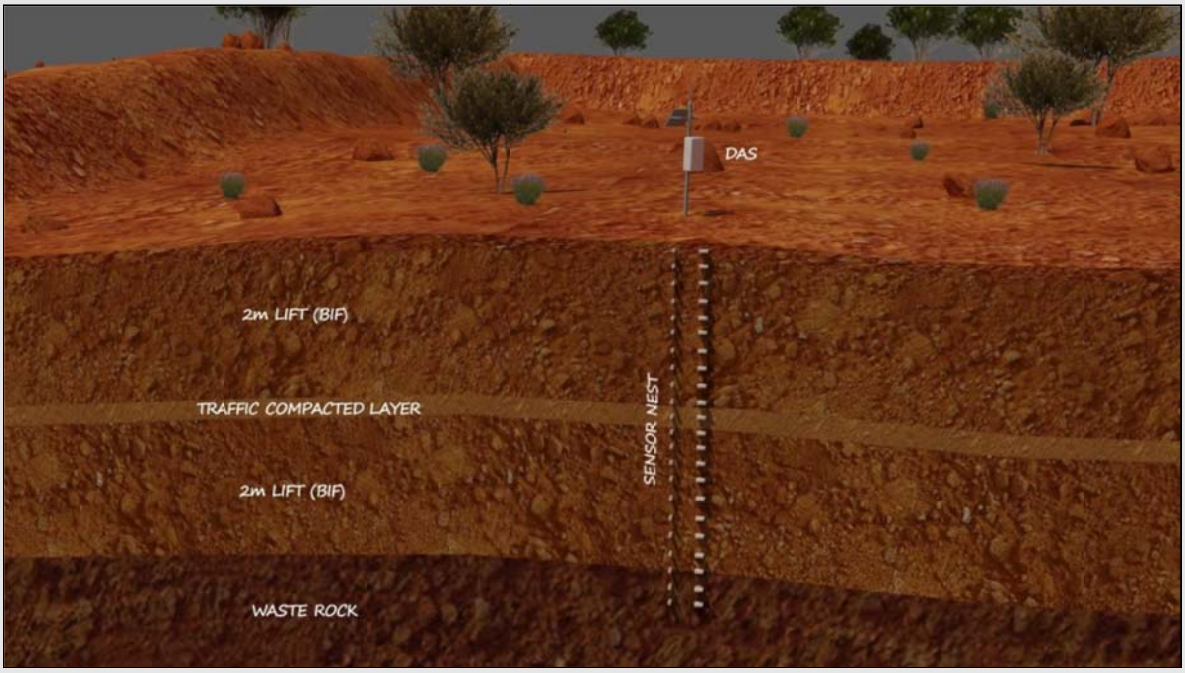
Source: BHP Billiton Iron Ore.
Yarrie: *Triodia* establishing in rehabilitation area

The Pilbara Seed Atlas project has significantly contributed to improved native seed viability over the long term, and the success of this is demonstrated through on-ground results.
Rehabilitation monitoring at Yarrie shows the early establishment of spinifex species in rehabilitation to have comparable density to the analogue sites within a two-year time frame.

The outcomes from all research are documented in BHP Billiton Iron Ore's rehabilitation procedures: for example, the Seed Management Procedure has details on minimum storage conditions required. These procedures underpin the Rehabilitation Standard (document 0001074) and provide the operational processes and protocols required to ensure standards are met. The Rehabilitation Standard was developed in 2011 to guide the process of rehabilitation of lands so that it that meets the expectations of stakeholders, enables the agreed end use objectives of the land to be met, meets the relevant regulatory and compliance requirements, and, ultimately, ensures that the completion criteria for all rehabilitation activities are met.

Case Study 11: Acid mine drainage and cover systems at Mt Whaleback

Past work at BHP Billiton Iron Ore's Mt Whaleback operation has shown that AMD is a risk for certain stratigraphies, including, for example, Mount McRae Shale. BHP Billiton Iron Ore has been developing cover system designs and waste rock management plans for the overburden storage areas at Mt Whaleback since 1995. BHP Billiton Iron Ore's management strategies have focused on cover system design, as well as landform and watershed designs, strategies that have evolved several times since 1995 in response to evolution of the conceptual models that have been developed at the site with respect to the mechanisms and the controls on those mechanisms resulting in AMD.



Schematic of W29 cover system layers and installed instrumentation Cover system performance monitoring at the Mt Whaleback site has been ongoing for 17 years. This substantial dataset has included collection of site meteorological, in situ moisture, temperature, matric potential, and pore-gas data, providing valuable information regarding the ongoing overburden storage area rehabilitation research program.

Case Study 12: Below the water table mining and management of the mine lakes – understanding the water balance

BHP Billiton Iron Ore and CSIRO are working together to undertake a field measurement campaign to develop a calibrated model of pan evaporation. This will represent lake evaporation, which will enable translation of findings to other locations and will describe the relationship between pan evaporation within the pit at lake-level (immersed pan) and meteorology at the natural surface and at Newman (standard pan).

Long-term geochemical stability and environmental sustainability depends on the balance of water fluxes into and out of these mine lakes, including precipitation, surface water inflow, evaporation and groundwater flows. There is uncertainty in all of these water balance components, with perhaps the greatest uncertainty surrounding the evaporation term due to the arid monsoonal climate of the Pilbara region.

Net evaporation from the mine lake surface is a significant and often problematic term in the water balance equation. Baseline data will be used by CSIRO and BHP Billiton Iron Ore to test physically based models and guide future investment to meet the needs of understanding the water balance of these lakes. The project objectives are to:

- compare mine void site data to data at Newman to quantify pan evaporation under prevailing natural conditions (standard pan) and at the mine void water surface (immersed pan);
- collect adequate data to run and validate a model of pan evaporation and to drive a model of lake evaporation; and
- test the model and compare measurements from the two pans under different meteorological conditions (wind speed and direction, air temperature and humidity, and different light conditions).

Source: BHP Billiton Iron Ore.

Automated evaporation pans compute daily evaporation.

Meteorological measurements include wind speed and direction, temperature and humidity at three heights above the natural surface and above the lake and at a point approximately one-third of the way up the mine side if possible.

Case Study 13: Overburden storage areas – preparing for rehabilitation

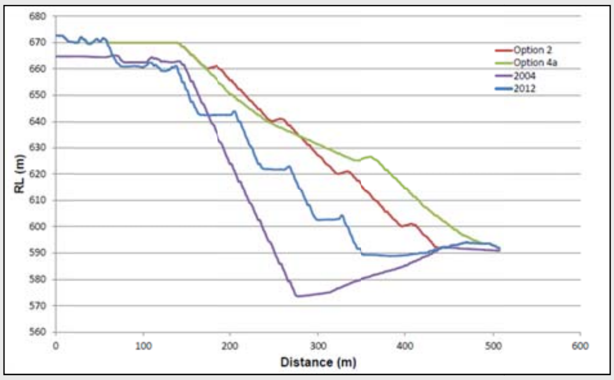
Mt Whaleback: Concave Landform (W19/W40 Overburden Storage Area)

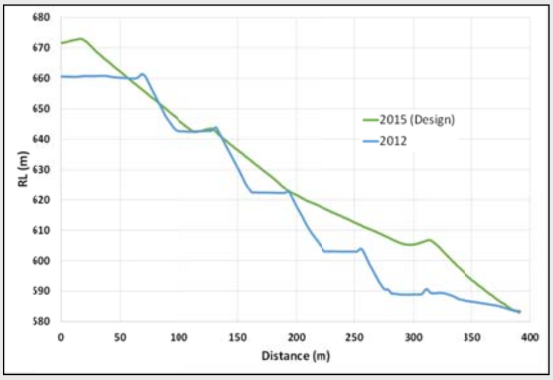
Environmental surface erosion modelling was undertaken on proposed closure landform design options at Mt Whaleback mine. Modelling was used to evaluate the predicted rates and locations of erosion on a final landform.

Source: BHP Billiton Iron Ore.

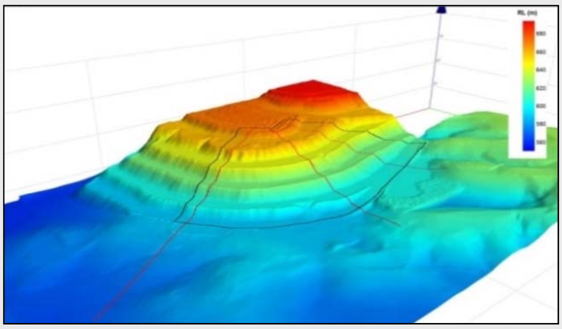
Side view of an overburden storage area slope at BHP Billiton Iron Ore's Mt Whaleback mine

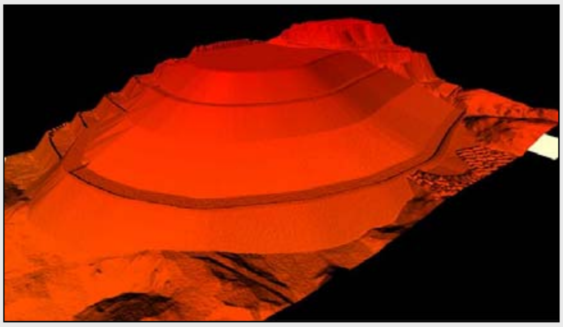
This process was supported by numerical inputs obtained from the material characterisation programs and local climate data. The numerical modelling was validated with physical modelling of erosion (undertaken in laboratory conditions using predicted rainfall events based on local rainfall data). This informed OSA design considerations regarding stable slope angles and material use given all other identified constraints.





Multiple design iterations were reviewed, including traditional berm and batter design and concave design options.





The chosen landform option required competent inert waste material selected specifically to fill the as-tipped design, which in turn enabled the final profile design to be executed.

Source: BHP Billiton Iron Ore.

Slope overburden storage area reprofiling work at BHP Billiton Iron Ore's Mt Whaleback mine

Ongoing monitoring in the field to ensure the reprofiled slope is compliant with design. Collaboration between BHP Billiton Iron Ore's Rehabilitation, Operations and Short Term Planning teams allowed for early resolution of any matters that may have compromised compliance to design.

Case Study 14: Post mining land use

Mining tenements and pastoral leases constitute the majority of land tenure in the Pilbara region. The most common post-closure land uses in Australia tend to be the restoration of the premining land uses, including attempts to re-establish native ecosystems or grazing land. National and international best practice is evolving beyond this, however, with greater innovation reflecting a higher level of commitment to the environmental, social and economic value of various post-closure land uses. Potential options for post-closure land use, include:

- pastoralism: e.g. establishment of a sustainable fodder crop;
- rehabilitation: e.g. re-establishment with native species appropriate to a modified landscape;
- native ecosystem conservation: e.g. re-establishment with native species appropriate to a modified landscape and protected by conservation covenants to contribute to the conservation and protection of conservation-significant assets and species, such as MNES protected under the EPBC Act and state significant species or communities protected under the Wildlife Conservation Act and EP Act.
- specialised habitat: e.g. artificial habitat creation, such as terrestrial habitats and wetlands;
- research and development project: e.g. research into arid zone rehabilitation or ecologically sustainable land use in the arid zone;
- capacity building initiative: e.g. mine training centre;
- alternative agriculture: e.g. algaculture; and
- recreational development: e.g. outdoor adventure activity recreation hub, potentially including rock climbing, mountain biking, abseiling, and four-wheel-drive vehicle use.

The matrix below presents a summary of opportunities and limitations. All post-closure land use options have the potential to satisfy legal requirements; however, some options are simpler or have a more risk-neutral profile to implement than others.

Key limitations in considering post-closure land use options include long-term land management arrangements (and associated liability risk) and resource sterilisation. Another major consideration is how ‘closure’ is defined, as interim land uses may at times be employed before the full transition to a land use that may be managed in perpetuity. Suitable options for post-closure land use may involve a combination of interim and final land uses for some sites.

Two considerations for post closure land use are key:

- post-closure land use must be considered early during closure scenario planning; and
- planning for post-closure land use must remain flexible, starting with the base case of pastoralism or native vegetation, but must enable the inclusion of best practice or legacy post-closure land uses in the future if feasible.

Post-closure land uses should be reviewed and revised as part of closure planning and should consider the effects of changes to external factors (climate change, demographics, sterilisation risk, etc.) on the opportunities and limitations for each. Other closure options (with new considerations) may become available over the life of the Strategic Proposal. Adaptive management will need to be applied as an understanding of post-closure land use options is further developed.

		Post-closure Land Use Options							
		Pastoralism	Rehabilitation	Native ecosystem conservation	Specialised habitat	Research facility (arid zones ecologically sustainable land use)	Capacity building (e.g., mining, military, agriculture)	Alternative agriculture (e.g. algaculture)	Recreational facility (e.g. rock climbing, mountain biking, abseiling, four-wheel driving, water sports)
Opportunities	May satisfy compliance requirements	✓	✓	✓	✓	✓	✓	✓	✓
	May promote community development	✓				✓		✓	✓
	May support continued resource development	✓	✓	✓			✓	✓	
	May enhance regional environmental knowledge		✓	✓	✓	✓			
	May contribute to reserving 10% to 15% of the bioregion		✓	✓	✓				
	May promote conservation of MNES or endemic species		✓	✓	✓				
	May be compatible with broader post-mining land use options				✓		✓		✓
Threats	May sterilise resource			X	X	X	X	X	X
	May affect long term land management arrangements, liability and divestment[1]			X		X	X	X	X
	May threaten compatibility with adjacent mining operations (safety/environment)			X	X				X
	May be affected by technical or legislative feasibility (engineering/environment)[2]		X	X	X			X	

[1] Such as requirements to offer rail or infrastructure to the state upon relinquishment.

[2] Based on current knowledge.

Table 83: Chronology of BHP Billiton Iron Ore's rehabilitation and closure activities in the Pilbara

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
1974-1977	Mt Whaleback	Mining started at Mt Whaleback in 1967, and the first trials were undertaken at Mt Whaleback in revegetation of constructed waste landforms to assist in the control of dust. Early trials aimed to develop an efficient, practical, and economic method of accelerating native vegetation and included some physical and chemical analysis of waste materials. Early experiments conclude: thinly spread fresh topsoil on prepared waste material is a viable method of establishing native vegetation; topsoil shortage identified over life of mine for rehabilitation; direct seeding of selected native species may be required; difficulties with achieving consistent *Triodia* establishment.
1981-1987		OSA rehabilitation undertaken using fresh topsoil on the reprofiled landform followed by contour ripping; dense establishment of mulga achieved. Mt Whaleback borrow pit rehabilitation (14 sites) undertaken within two years of the disturbance occurring. Included reprofiling, respread of topsoil, and ripping contours. Outer wall of the Newman hub beneficiation-tailings dam rehabilitation works completed having been ripped with a grader and hand seeded. Dominant growth of *Acacia pyrifolia* established across the wall.
1988		Borrow pit rehabilitation undertaken within 12 months of the disturbance occurring. Included: reprofiling, respread of topsoil, and contour rip.
1990	Mt Whaleback	Moonscaping of rehabilitation areas to increase water harvesting potential first undertaken.
	Jimblebar	Borrow pits rehabilitated along the Jimblebar rail spur. Included: reprofiling, respread of topsoil, and contour rip.
1991	Yandi	Borrow pits rehabilitated along the Yandi rail spur. Included: reprofiling, respread of topsoil, and contour rip.
	Jimblebar	Rehabilitation trial comparing topsoil areas with no seed or fertiliser applied and without ripping initiated.
1992	Mt Goldsworthy	First total site decommissioning: Mt Goldsworthy officially closed after 26 years of operation (mining ceased in 1982; BHP Minerals acquired Goldsworthy Mining in 1990).
	Ethel Creek	Rehabilitation of degraded areas of the Fortescue floodplain undertaken between 1992 and 1995 with Curtin University Mulga Research Centre on Ethel Creek Station.
	Jimblebar	Wheelarra Hill western fines OSA rehabilitation undertaken. Reprofiled OSA slopes to 20 degrees, topsoil applied, fertilised and seeded.
1993	Eastern Ridge	In-pit waste landform rehabilitation and topsoil trials initiated at Orebody 25, including topsoil and no topsoil application, some seeded areas. Trial results (2001) indicated that good success with native vegetation establishment best with topsoil and seed application; however, poor consistency with *Triodia* establishment.
	Mt Goldsworthy	Seeding 300 ha completed the rehabilitation works at Mt Goldsworthy (initiated in 1992), including mine, townsite and industrial areas. First large-scale

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
		demonstration of scalloping across constructed waste landforms. No topsoil available for rehabilitation works.
	Mt Goldsworthy	First fauna monitoring program with visual observations and invertebrate collection undertaken at Mt Goldsworthy (rehabilitation less than one year old).
1994	Nimingarra	590 ha rehabilitation across waste landforms at Nimingarra and Sunrise Hill. All landform slopes scalloped (dimpled to retain water and create a better growing environment), all areas seeded, no topsoil available.
	Mt Whaleback	South wall lift of beneficiation-tailings dam constructed and seeded.
		Initiation of formal planned rehabilitation monitoring program at Mt Whaleback.
	Jimblebar	Wheelarra Hill western fines OSA rehabilitation (1992) remediation works undertaken to address erosion issues.
1995	Shay Gap	Shay Gap mine (330 ha) and town site (270 ha) rehabilitated. All landform slopes scalloped, all areas seeded, no topsoil available.
1995	Jimblebar	Wheelarra Hill Site A pit area rehabilitated using fresh topsoil (no seed applied). Site lost in 2000 due to continuous mine development.
1997	Jimblebar	Rehabilitation monitoring review identifies the degree of spinifex (*Triodia* spp.) establishment as the most obvious distinction between rehabilitation areas and undisturbed vegetation; some areas with significant erosion noted and related to waste materials having insufficient ‘blocky’ content.
1997	Mt Whaleback	Rehabilitation monitoring review at Mt Whaleback identifies that, with the exception of one rehabilitation area where direct placement of topsoil occurred (W06 trial, 1977), *Triodia* was typically absent from rehabilitated sites. Three areas (rehabilitated 1985 and 1981) considered to have cover of perennial vegetation that approximated the level observed in the analogue. Other sites demonstrated comparatively poorer revegetation success.
		Early study undertaken of recolonisation by ants and small vertebrates in rehabilitated areas.
1998	Mt Whaleback	Erosion assessment undertaken with the University of Western Australia to develop a guideline for controlling surface erosion on rehabilitated waste landforms.
		Ant fauna survey on six rehabilitated sites at Mt Whaleback finds lower species richness of ants in rehabilitated areas when compared to control sites, suggesting these areas lack required microhabitat or other resource requirements due to poor vegetative cover and low density of perennial plant species.
		Moonscaping of W31 waste OSA rehabilitation undertaken.
	Nelson Point	East Creek rehabilitation at Nelson Point involving the restoration of regular tidal flows through the creek via establishing three new channels to encourage re-establishment of mangroves.

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
	Eastern Ridge	Orebody 25 Pit 1 North Wall rehabilitation, including recontouring of upper benches of the pit wall and topsoil application.
	Yarrie	Yarrie Y10 waste landform upper slope rehabilitated, linear slope, topsoil, no seed applied.
1999	Yandi	Yandi Eastern 2 waste landform rehabilitation undertaken using a linear approach, some areas with topsoil spread.
	Eastern Ridge	Orebody 25 Pit 3 rehabilitation of landform crest undertaken, most areas with topsoil spread.
2000	Yarrie	Y10 waste landform mid slope rehabilitated, linear slope, no topsoil, and seed applied.
	Jimblebar	Wheelarra Hill old magazine area rehabilitated (seeded and ripped).
		Wheelarra Hill eastern waste landform (W6) rehabilitation trial with three treatments applied, including topsoil applied across the crest, scalloped slope, and contour-ripped slope.
2001	Mt Whaleback	Cover system trial established at Mt Whaleback W29 and W22 waste landforms.
		Mt Whaleback W29 seed germination trial: concluded temperatures at the time of the trial were likely too low to stimulate germination of species trialled. *Senna notablis* had the highest germination rate followed by *Acacia bivenosa,* with no germination for *Senna leursennii* and *Triodia wiseana.*
	Yandi	Yandi first fauna survey undertaken in rehabilitation areas.
2002	Nimingarra	2001 fire across part of the 1995 rehabilitation at Nim A enables a study of the effects of fire on rehabilitation.
	Mining Area C	Mining Area C borrow pits and exploration (Packsaddle) camp area rehabilitated with areas reprofiled to blend into the undisturbed landscape, topsoil spread and the camp area also seeded.
	Yandi	Yandi borrow pit rehabilitation completed with areas blended into undisturbed landscape and topsoil spread.
2003	Yandi	Yandi rehabilitation fauna surveys indicate sites being utilised by a number of vertebrate and invertebrate species. Colonisation by insectivorous mammals and reptiles indicates the relative density of invertebrates across the site.
		Yandi E2 waste landform rehabilitated using a linear approach with topsoil applied. Seeding not undertaken until 2004.
		Yandi borrow pit rehabilitation completed with areas blended into undisturbed landscape and topsoil spread.
	Yarrie	Yarrie Y10 waste landform mid slope rehabilitated, linear slope, no topsoil, contour ripped and seed applied.

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
	BHP Billiton Iron Ore–wide	First rehabilitation specialist employed to support rehabilitation outcomes across BHP Billiton Iron Ore Pilbara operations.
2004	Yarrie	First detailed mine waste rock characterisation studies undertaken at Yarrie, Shay Gap, and Nimingarra.
	Eastern Ridge	1993 Orebody 25 in-pit waste landform rehabilitation trial areas lost as part of continuous mine development.
2005	Mt Whaleback	Vegetation assessment of Mt Whaleback W29 cover system trial determines: establishment of native species varied, with seedling recruitment from topsoil bank (no seed applied) evident; and even highest seeding rates of native species resulted in low establishment rates with poor to no *Triodia* spp.
	Yarrie	Yarrie W1 waste landform surface treatment trial established. Trial recommendations: contour banks not appropriate to climatic conditions; scalloping not ruled out; however, erosion occurred due to poor interlocking cells; contour ripping requires further investigation, including use of winged tynes and multi tynes.
	Yandi	Rehabilitation of the Yandi Central waste landform using a linear approach, topsoil, and seeding.
	BHP Billiton Iron Ore–wide	Establishment of BHP Billiton Iron Ore Closure Principles.
2006	Mt Whaleback	Mt Whaleback W31 waste landform reworked (W02 1981); linear approach across the slope, topsoil and seed applied.
2007	Yandi	Yandi W04 waste landform rehabilitation; linear approach across the slope with topsoil applied (no seed).
	Mining Area C	Mining Area C C-West waste landform two lifts (linear) rehabilitated with topsoil applied (no seed).
	Jimblebar	Wheelarra Hill WD5 waste landform northeastern batter rehabilitated across a linear slope with topsoil applied (no seed).
2008	BHP Billiton Iron Ore–wide	Pilbara Seed Atlas initiated with partnership established between BHP Billiton Iron Ore and Botanic Gardens and Parks Authority.
	Yarrie	Yarrie W1 waste landform (slope and berm) linear approach with contour ripping, topsoil on slope, berm laterite growth media and seed.
	Mining Area C	Mining Area C borrow pit areas rehabilitated within 12 months of disturbance; areas reprofiled to blend into undisturbed landscape with topsoil respread.
	Eastern Ridge	Orebody 23 waste landform western face rehabilitated following geofluvial approach with modelled landform based on surrounding topography. Topsoil applied (no seed).
2009	Mining Area C	Mining Area C E-East waste landform lower lift (linear profile) rehabilitated with topsoil and seed applied.

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
	Jimblebar	2008 fire near Orebody 18 allowed an initial fire succession study to be undertaken: species assemblages reflected climatic factors; *Triodia* cover experienced an initial rapid increase followed by reduced rigour potentially caused by lower annual rainfall.
		Jimblebar rail spur borrow pits rehabilitated within 12 months of disturbance; areas reprofiled to blend into undisturbed landscape with topsoil respread.
	Yandi	Marillana borrow pits rehabilitated within 12 months of disturbance; areas reprofiled to blend into undisturbed landscape with topsoil respread.
		Yandi Central OSA rehabilitated, linear approach with contour ripping, topsoil applied (no seed).
		Yandi old batch plant rehabilitated, reprofiled to blend into undisturbed landscape with topsoil respread (no seed).
	Eastern Ridge	Orebody 23 waste landform eastern face rehabilitated following geofluvial approach with modelled landform based on surrounding topography. Topsoil and seed applied.
	Yarrie	Yarrie W1 waste landform (slope and berm) linear approach with contour ripping, topsoil and laterite growth media, and seed.
2010	Eastern Ridge	Orebody 23 OSA second lift western side rehabilitation (geofluvial approach, topsoil applied, no seed) and seeding of eastern rehabilitation area; remediation works undertaken on 2009 rehabilitation area to address erosion.
	Mt Whaleback	Mt Whaleback W41 soak cells constructed; all internal surfaces ripped and seeded.
	Yandi	Yandi Central waste landform rehabilitation; linear approach across the slope plus crest; topsoil and seed applied.
2011	BHP Billiton Iron Ore–wide	BHP Billiton Iron Ore Rehabilitation Standard and procedures adopted.
		BHP Billiton Iron Ore Rehabilitation Strategy developed.
		Seed sourcing strategy established to address quality control, provenance and seasonal variation.
	Yarrie	Yarrie Y7 in-pit waste storage area and haul roads rehabilitated; contour ripped, topsoil and laterite mixed growth media applied and seeded.
		Yarrie topsoil seed bank trial results (2009 to 2011) demonstrated 12-month topsoil stockpile had lowest germination response, with similar germination response from freshly spread topsoil and from a three-year-old topsoil stockpile.
		Yarrie Hawks Head waste landform and haul roads rehabilitated following linear approach for slopes. Laterite growth media applied to flat areas (none on slopes), all areas seeded.

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
		Yarrie C-Pit in-pit waste landform rehabilitated following linear approach for slopes. Topsoil and laterite growth media applied, all areas seeded.
	Mining Area C	Mining Area C E-East waste landform middle and upper lifts (linear profile) rehabilitated with topsoil and seed applied.
	Yandi	Yandi ore handling plant, rail loop and laydown area rehabilitated with areas reprofiled to blend into undisturbed landscape with topsoil respread.
	Rail	Chichester Deviation: Rehabilitation of construction and borrow pit areas, reprofiled to blend into undisturbed landscape with topsoil respread.
2012	BHP Billiton Iron Ore–wide	Rehabilitation Constraints Review undertaken to identify key blocks and potential enablers in achieving successful on-ground rehabilitation through planning to execution. Results of review inform Rehabilitation Strategy.
		BHP Billiton Iron Ore leads the establishment of the Pilbara Restoration Initiative, an industry forum whose purpose is to improve success in all aspects of rehabilitation through targeted, collaborative research and development.
	Mt Whaleback	Waste characterisation used to develop preliminary slope design for Mt Whaleback W19 waste landform informed by Water Erosion Prediction Project models.
	Mining Area C	Mining Area C rock armour trial established with nine trial plots, enables collection of data on runoff and erosion to allow assessment of effectiveness of different surface treatments in limiting erosion.
		Progressive rehabilitation of OSAs stopped at Mining Area C due to significant levels of erosion across rehabilitated areas.
2013	BHP Billiton Iron Ore–wide	Detailed waste characterisation and erosion potential modelling studies initiated across all mine sites.
		Restoration Seed Bank Initiative established: a five-year partnership between BHP Billiton Iron Ore, the University of Western Australia and the Western Australian Botanic Gardens and Parks Authority.
		BHP Billiton Iron Ore leads the formation (and chairs) the Pilbara Rehabilitation Group, an industry forum supporting open communication and discussion between members to share learnings and experience, working towards improving mining rehabilitation outcomes in the Pilbara region.
	Finucane Island	Finucane Island Berm 1 rehabilitation: first rehabilitation project across BHP Billiton Iron Ore to have been executed using waste characterisation to inform final landform design.
	Cattle Gorge	Waste characterisation used to develop final slope design for Cattle Gorge waste landforms informed by Water Erosion Prediction Project models.
2014	BHP Billiton Iron Ore–wide	Pilbara Seed Provenance Study initiated: a three-year collaboration between Department of Park and Wildlife, BHP Billiton Iron Ore and Rio Tinto Iron Ore.
		Joint BHP Billiton Iron Ore and Rio Tinto Iron Ore rehabilitation presentation to EPA Board as a response to the 2013 EPA annual report stating no demonstrated

YEAR	LOCATION	REHABILITATION AND CLOSURE ACTIVITIES
		rehabilitation success in the Pilbara.
		BHP Billiton Health, Safety and Environment Awards - Environment: Sowing the Seeds of Success. Finalist Highly Commended project on the improvements achieved in rehabilitation projects since the adoption of the 2011 seed sourcing strategy.
		BHP Billiton Iron Ore draft and implementation of a Regional Closure and Rehabilitation Management Strategy (BHP Billiton Iron Ore 2014b) covering all of its Pilbara operations. The regional strategy was presented to the Western Australian Department of Mines and Petroleum.
	Mt Whaleback	Rehabilitation of historic disturbance areas undertaken near Mt Whaleback, removing rubbish, recontouring, scarifying and seeding.
	Yandi	Rehabilitation works covering numerous redundant infrastructure areas across the Yandi mine site, recontouring, topsoil spread and scarifying.
	Yarrie	Yarrie Y10 Sisters rehabilitation of waste landforms and haul roads. Reprofile and blending of benches and windrows, laterite growth media applied and seeded.
2015	BHP Billiton Iron Ore–wide	Restoration Seed Bank Think Tank with site visits to Mt Whaleback and Mining Area C mine sites supported through the Restoration Seed Bank Initiative; brought together for a week experts in the field of landscape restoration, with nine Australian and four international representatives for the purpose to review the latest in rehabilitation practices and brainstorm solutions for native plant establishment with the aim to develop improved, cost-effective approaches to rehabilitation of mined areas.
2015	Mt Whaleback	W19 OSA rehabilitation completed: first large-scale landform rehabilitation project to be completed following new process of the design criteria being informed by the properties of the waste materials.

8.5.3 OFFSETS

Where significant residual impacts are identified following rehabilitation, BHP Billiton Iron Ore will provide environmental offsets. A strategic proposal enables consideration of environmental offsets as part of a long-term regional approach, something typically not undertaken as part of project-by-project assessment. Thus, it provides a unique opportunity for BHP Billiton Iron Ore to consider offsets that have strategic outcomes, are coordinated and are developed to address regional- or landscape-scale residual impacts and threatening processes.

Contemporary environmental offset guidance in Australia at both the state and Commonwealth level focuses, in the main, on individual project offsets and offers no incentives for alignment with other offsets proposed or being implemented within a region. Recent initiatives in Australia have tried to be more proactive in coordinating regional outcomes, for example, the Galilee Basin Offset Strategy that seeks to 'support the strategic location of offsets in areas where the range of values to be lost from potential development occur. These "offset investment hubs" will be used to manage and protect those values to ensure long-term environmental outcomes at the wider landscape scale.' (EHP 2013).

BHP Billiton Iron Ore recognises that a more strategic focus to offsets can potentially deliver greater environmental outcomes over a larger area and longer time frame than would otherwise be the case. This is particularly relevant to offsets in the Pilbara, where underlying tenure complications mean that traditional land acquisitions are generally not a viable offset alternative, as discussed in Western Australian environmental offsets guidelines (EPA 2014b):

> For the extensive land use zone of the State where land is almost exclusively Crown land overlain by pastoral leases and mining provinces, a different approach is needed as there is almost no opportunity for land acquisition to occur…. The use of a strategic approach, such as a fund, is a solution to overcome land use tenure issues by providing a coordination mechanism to implement offsets across a range of land tenures. This type of approach may be suitable to apply in the extensive land use zone.

This and other challenges for delivery of offsets in the Pilbara are recognised in the contemporary offset guidance from both the Western Australian EPA and the Commonwealth DotE. Both also recognise that different offset solutions may be appropriate to strategic assessments, such as this guidance from the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (DSEWPaC 2012b):

> Proposed new strategic assessments may consider alternative metrics other than the Offset assessment guide (e.g. if a jurisdiction has developed a metric tailored to their needs) provided the principles of this policy are met.

The EPA has proposed the establishment of a strategic conservation initiative for the Pilbara as a mechanism to pool offset funds to achieve broad-scale biodiversity conservation outcomes (Cumulative Environmental Impacts of Development in the Pilbara (EPA 2014a)). The initiative would align with principle 6 of the Western Australian Environmental Offsets Policy (Government of Western Australia 2011) to focus offsets on longer-term strategic outcomes. The initiative is currently being referred to as the Pilbara Conservation Fund, and the EPA has recently commenced a series of stakeholder workshops to assist in the development of the fund's objectives, approach, governance and offset metrics.

A recent series of Pilbara threatened-species workshops conducted by the Western Australian Department of Parks and Wildlife (in 2013/14) and a subsequent study undertaken by CSIRO (Carwardine et al. 2014) have confirmed the key threatening processes to species and the ecology of the Pilbara. This work has identified that the top three most cost-effective strategies for investment in land management actions in the entire Pilbara are:

- management of feral ungulates;
- sanctuaries; and
- cat management.

There has been considerable recent success in the development and implementation of conservation and offset initiatives to address these threats in the Pilbara, including on-ground projects undertaken by Rangelands NRM (Pilbara Corridors Project) and Greening Australia (Aboriginal Landcare Education program). These projects have included feral animal control, weed control and land use management and have been undertaken in conjunction with land managers in the Pilbara, including pastoralists and Aboriginal groups.

The BHP Billiton Iron Ore outcome-based objective for Offsets is:

- Offsets: BHP Billiton Iron Ore shall counterbalance any significant residual environmental impacts or uncertainty through the application of appropriate, effective and enduring offsets.

Following from the above, BHP Billiton Iron Ore believes that the best approach to addressing environmental offsets as part of the Strategic Proposal is an approach that:

- is at the regional or landscape scale;
- meets the requirements of both the state and Commonwealth offset obligations;
- implements conservation actions in a coordinated way based on clear investment decisions and targeted outcomes;
- focuses on the highest-priority biodiversity issues (key threatening processes) in the region through the delivery of on-ground initiatives that are proportionate to potential residual impacts;
- has initiatives delivered by third parties experienced in such programs within the Pilbara;
- provides opportunities for partnerships between government, industry, landholders and Aboriginal communities;
- is transparent, with robust governance arrangements that can be readily measured, monitored and audited; and
- will be applied within an adaptive management framework.

The Pilbara Conservation Fund has the potential to deliver on these objectives. While the fund has yet to be endorsed by the Western Australian Government and the mechanics and governance of the fund have not been developed, BHP Billiton Iron Ore endorses the fund in principle as the mechanism through which it will meet its environmental offset obligations for the Strategic Proposal. BHP Billiton Iron Ore will reserve commitment to the fund until such time as these arrangements are in place.

Should the fund not eventuate or be proposed in a form that does not meet the objectives detailed above, the offsets would be delivered consistent with contemporary offset guidance, to the satisfaction of the EPA. The preferred offsets approach would be confirmed at the Derived Proposal stage.

Based on the area of potential direct impact (Table 19), approximately 98,066 ha of Good or better quality vegetation will potentially be directly impacted by the BHP Billiton Iron Ore Full Conceptual Development Scenario. Only 108,994 ha of the total 124,666 ha Full Conceptual Development Scenario footprint has been mapped for vegetation condition, representing approximately 87% of the Full Conceptual Development Scenario footprint. These unmapped areas include the proposed Roy Hill and Ministers North tenements, parts of Ophthalmia / Prairie Downs tenure and parts of the Newman mining hub. Given that the majority of the mapped areas represent Good to Excellent vegetation, it is likely that unmapped areas are also Good to Excellent.

The success of rehabilitation as a mitigation measure will be determined by a number of factors. For the purpose of estimating the quantum of residual impact, it has been assumed that rehabilitation will have achieved successful mitigation if vegetation of good or better quality is establish that it is consistent with the final land use as defined in the mine closure plan. As discussed in Section 8.5.2.1, BHP Billiton Iron Ore believes that this level of success can be achieved on areas disturbed for OSAs, rail, and associated infrastructure (but not pits). On this basis, the potential scale of the residual impact from development of the BHP Billiton Iron Ore Full Conceptual Development Scenario is approximately 50,316 ha (see Table 81).

This figure and the scale of each future proposal offset will be validated and set at the Derived Proposal stage. The acceptance of rehabilitation as a mitigation measure will require ongoing verification of rehabilitation success.

8.5.4 SUMMARY OF ASSESSMENT OUTCOME

The EPA's determination as part of the Strategic Proposal referral and as outlined in the ESD (BHP Billiton Iron Ore 2013) was that Integrating Factors (Rehabilitation and Decommissioning and Offsets) were key preliminary environmental factors. Rehabilitation and Decommissioning (closure) includes the forward planning and execution of activities related to closing a mine, rehabilitation of the land and decommissioning or transfer of infrastructure (including rail) when operations have ceased. Offsets include implementing measures that provide environmental benefit to counterbalance significant residual impacts that cannot be mitigated with rehabilitation and decommissioning activities.

The impacts associated with the Strategic Proposal that will, when unmitigated, affect BHP Billiton Iron Ore's ability to meet its objective for Rehabilitation and Decommissioning are:

- **Permanent modification of landforms:** The construction and operation of open-cut mines and the associated infrastructure can result in the modification of landforms. These modifications may have adverse impacts on environment values (e.g. removal of habitat) or social values (e.g. impact to visual amenity).
- **Impacts to hydrological processes:** Open-cut mining in the Pilbara has the potential to impact the hydrological (surface water) and hydrogeological (groundwater resources) regime at closure.
- **Permanent modification of vegetation and habitat**: Some landforms will be modified extensively from their original state, as will the vegetation and habitats that those landforms support; therefore, rehabilitation of vegetation and habitats may not be able to achieve outcomes that represent predisturbance or reference site conditions.
- **Contamination of soils and water:** Soil and water contamination impacts within the context of mine closure and rehabilitation can include, among other impacts, increased turbidity in surface water due to surface erosion of final landform and acidification of surface water bodies (natural or artificial) due to exposure to AMD.

The development of the mine closure plans will provide the conceptual completion criteria and closure options for the specific site, supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. Throughout the operations phase, iterations of the mine closure plan will progressively refine the closure options with available data, enabling detailed designs and completion criteria to be developed and progressive rehabilitation works to occur. As mining draws to a close, the detailed closure designs will be executed, and the site will move into the post-closure period of monitoring, reporting, completion and sign off. In all cases, the focus for the application of the relevant controls is on achieving the defined completion criteria and following the mitigation hierarchy of control. This PERSP and its supporting documents have provided information on:

- rehabilitation and closure research (Section 8.5.2.3) and supporting case studies;
- pit lakes assessment as a component of the ecohydrological change assessment (Appendix 7) and management;
- managing and mitigating AMD risk using a structured approach, consistent with global leading practice guidelines. AMD management is risk based and refined with increasing geochemical knowledge of waste material, and this knowledge is integrated into the closure plan. The information informs the decision-making process for OSAs, pit closure and mine void management (Appendix 7);
- adaptive management, which maintains rehabilitation and closure planning flexibility to accommodate changes in method or technology that are developed more broadly in the mining, closure and rehabilitation industry (Section 12.1.1); and
- rehabilitation methods (Section 8.5.2.2 and Section 8.5.2.3).

BHP Billiton Iron Ore has a suite of management and control measures, based on extensive operating experience in the Pilbara region, to ensure effective closure and progressive rehabilitation and to minimise the associated impacts. These include:

- regional management approach (Chapter 6 and Section 12.1);
- adaptive management and the mitigation hierarchy;
- Rehabilitation and Decommissioning Management toolkit; and
- mine closure plans.

BHP Billiton Iron Ore has applied the significance framework detailed in the EPA Environmental Guideline 9 (EPA 2015b) during the assessment of this Strategic Proposal. Given the Company’s historical performance with rehabilitation and decommissioning, and the application of the management processes (Chapter 6 and Chapter 12) and preparation of mine closure plans, BHP Billiton Iron Ore considers that potential impacts can be managed to an acceptable level to meet EPA’s factor objective through targeted management in addition to business-as-usual management.

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9 IMPACT ASSESSMENT CONCLUSIONS

The Strategic Proposal is supported by the knowledge from more than 50 years of resource exploration, development, operation and monitoring of mines in the Pilbara. This experience has contributed to a strong understanding of the Pilbara landscapes and has included an ongoing program of studies and investigations and the collection of environmental survey data. In aggregate, this experience and knowledge has provided important insights into systems of the Pilbara and has supported the formulation and assessment of potential impacts and management approaches in BHP Billiton Iron Ore's mining areas. The knowledge is based on more than 350 individual baseline reports commissioned by BHP Billiton Iron Ore over the last decade, as well as on supporting studies undertaken by BHP Billiton Iron Ore internal specialists and by a wide consultancy base that have been verified by independent peer reviews by subject matter experts. This wealth of baseline knowledge provides BHP Billiton Iron Ore with increased confidence in the assessment of potential impacts and the Company's ability to manage impacts to an acceptable level.

9.1 Validation of Key EPA Factors

The preliminary assessment of factors completed as part of the ESD (BHP Billiton Iron Ore 2013) has been validated throughout the PERSP. The results of further studies have aligned with the ESD findings in that the key environmental factors identified in the ESD have remained consistent. Those factors with a higher level of sensitivity and greatest potential magnitude of impact assessed in this PERSP are:

- Flora and Vegetation;
- Terrestrial Fauna;
- Subterranean Fauna;
- Hydrological Processes;
- Inland Waters Environmental Quality;
- Rehabilitation and Decommissioning; and
- Offsets.

Those factors with low sensitivity and low potential magnitude of impact assessed in this PERSP are:

- Terrestrial Environmental Quality;
- Landforms;
- Amenity; and
- Air Quality and Atmospheric Gases.

The EPA did not determine Heritage to be a key factor in its assessment of the Strategic Proposal referral. Nonetheless, the ESD (BHP Billiton Iron Ore 2013) makes a commitment to draw on the large body of knowledge that BHP Billiton Iron Ore has gained though archaeological and ethnographic surveys to provide regional heritage and ethnographic context relevant to the Strategic Proposal. The ESD identifies the need to define process arrangements for considering heritage impacts from future projects and to undertake consultation with relevant Native Title groups.

A separate assessment for Human Health has not been undertaken as it is considered that, at the strategic level, the key aspects impacting human health are adequately addressed through the Air Quality and Atmospheric Gases, Amenity and Terrestrial Environmental Quality factors.

9.2 Impact Assessment Outcomes

The PERSP provides an assessment of the potential for environmental impacts over the life of the Strategic Proposal and highlights those factors, and aspects within those factors, that have the greatest potential for impacts. The assessment of individual factors for the 30% Conceptual Development Scenario and Full Conceptual Development Scenario has identified a number of factors that without mitigation may be subjected to significant potential inherent impacts and that the EPA objective for the factor may not be met. The highest potential impacts correspond with the key environmental factors identified in the ESD (Table 84).

The Strategic Proposal regional management approach (described in Chapter 6 and presented within relevant sections throughout Chapter 8) provides a process for managing potential environmental impacts. This is underpinned by adaptive management, which provides a structured, iterative process of decision-making with the capacity to validate predicted impacts and to develop appropriate responses to emerging issues through monitoring and adapting to environmental, economic and social changes. An integral component of adaptive management is the application of the mitigation hierarchy (avoid, minimise, rehabilitate and offset).

This approach provides clear guidance for management plans, which will be developed and implemented (when relevant) at the Derived Proposal stage, to manage predicted impacts to key environmental factors as mining operations are progressively developed.

A series of case studies have also been presented that demonstrates that the approach and management controls considered in this PERSP are currently being implemented successfully across BHP Billiton Iron Ore projects within the Pilbara and shows the Company's commitment to improving environmental performance and managing environmental outcomes.

Table 84 includes the EPA and BHP Billiton Iron Ore objectives for each factor, a summary of the cumulative impact assessment results and the regional management approach. The relationship between sensitivity to impact, the level of uncertainty and the magnitude of the impact for each factor is assessed. Those factors with higher sensitivity and uncertainty will require a greater level of management and potentially require validation at the Derived Proposal stage. Factors with lower impacts and sensitivity, such as Air Quality and Atmospheric Gases and Amenity (including noise and visual amenity), are typically managed using standard management practices during construction and operational phases of a project. This is consistent with BHP Billiton Iron Ore's operational experience in the Pilbara and existing approval requirements.

Given BHP Billiton Iron Ore's history and knowledge of operating iron ore mines and infrastructure in the Pilbara, as well as the Company's proven track record in environmental stewardship, the findings of the impact assessment studies in this PERSP and the regional management approach presented, it is considered that implementation of the Strategic Proposal will meet the EPA's objectives.

Table 84: Strategic Proposal impact assessment summary table

IMPACT RATING LEGEND
Potential inherent impact (without mitigation):

- Impacts not discernible at a regional scale. The factor is well understood (high knowledge level) and there is a high level of certainty that acceptable outcomes will be achieved. Low impact to key assets and significant species.
- Potential impact at a regional scale; negligible to low impact to key assets and significant species. Further studies will be used to validate predicted impacts.
- Potential impacts at a regional scale and moderate to high impacts to key assets or significant species. Requires further studies or validation to address uncertainty.

Potential residual impact (with mitigation):

- Impacts considered to meet EPA's factor objective through business as usual (BAU) management standard. High level of certainty that acceptable outcome will be achieved.
- Impacts considered to meet EPA's factor objective through targeted management in addition to BAU management. Moderate to high level of certainty acceptable outcome will be achieved
- Impacts considered unlikely to meet EPA's factor objective.

Regional Biodiversity Values	
EPA Objectives and BHP Billiton Iron Ore Objectives *for Regional Biodiversity are stated in each of the Factor sections and summarised in Section 8.1.1.1.*	
Potential Impacts	**Management Approach**
The Full Conceptual Development Scenario footprint does not overlap with Karijini National Park or Mungaroona Range Nature Reserve. Some indirect impact to Karijini could occur from dewatering activities and visual amenity; these are discussed in respective sections. There is potential for direct impact to the Juna Downs pastoral lease exclusion area. The footprint overlaps the Ethel Gorge Aquifer Stygobiont Community TEC is by approximately 10% (4% when only pits are considered, which is more relevant to this TEC). The footprint overlaps 0.06% of the Vegetation of Sand Dunes of the Hamersley Range/Fortescue Valley PEC; and 2.24% of the Coolibah-lignum Flats PEC Subtype 1: Coolibah and mulga woodland over lignum and tussock grasses on clay plains (Coondewanna and Wannamunna flats). In addition, the footprint overlaps buffer areas for the Fortescue Marsh (Marsh Land System) PEC, Weeli Wolli Spring Community PEC; and Four Plant Assemblages of the Wona Land System PEC. Regional biodiversity modelling indicates that parts of BHP Billiton Iron Ore's tenure contain areas of predicted high biodiversity significance. These areas align with the above PECs and TECs and also other areas some as high mountain tops and drainage lines.	BHP Billiton Iron Ore considers that current ranking frameworks for the significance of environmental assets and communities, in this case conservation estate, and TECs, provide the most appropriate ranking inputs to prioritise mitigation. Applying the tiered system described in Section 6.2, to prioritise and rank our management objective in relation to conservation estate, and TECs places these within the highest tier (Tier 1). PECs may largely be placed in Tier 2, with the opportunity to opportunistically review their ranking on a case-by-case basis. For Tier 1 assets, BHP Billiton Iron Ore will define the mitigation measures, to be applied from the Land and Biodiversity Management Toolkit within management plans. The Derived Proposal process allows the consideration of environmental change in the future, including changes to boundaries of the existing conservation estate, PECs and TECs and the gazettal of new conservation estate.

Acceptability of Impact	
BHP Billiton Iron ore considers that potential impact within the Juna Down pastoral lease exclusion area will be managed to an acceptable level given the stakeholder engagement activities that BHP Billiton Iron Ore has committed to for any future Derived Proposal referral. BHP Billiton Iron Ore recognises that both direct and indirect impacts to TECs and PECs will require effective management to ensure that objectives for Tier 1 and Tier 2 assets are met. For example, management of the groundwater regime at Ethel Gorge will maintain stygofauna habitat and is one of the principle considerations in BHP Billiton Iron Ores regional water management planning for the Eastern Pilbara. BHP Billiton Iron Ore considers that, given its operational experience in managing impacts to surface water and groundwater in the Pilbara, impacts to these environmental assets managed to an acceptable level.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor - Flora and Vegetation

EPA Objective – to maintain representation, diversity, viability and ecological function at the species, population and community level.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to flora and vegetation from its activities to an acceptable level.

<table>
<tr><th>Potential Impacts</th><th>Management Approach</th></tr>
<tr><td>Beard vegetation associations, 18 (low woodland; mulga (Acacia aneura)) and 216 (low woodland; mulga (with spinifex on rises)), may be impacted by BHP Billiton Iron Ore from the Full Conceptual Development Scenario footprint by 5.2% and 17.4% of their pre-European extent in Western Australia respectively. The consolidated mapping on BHP Billiton Iron Ore tenure has highlighted that some mapped vegetation associations have a small (i.e., less than 20 ha) mapped extent across BHP Billiton Iron Ore tenure, or occur largely within the Full Conceptual Development Scenario footprint.

The majority of mapped vegetation within the Full Conceptual Development Scenario footprint is mapped as Good to Excellent condition. Vegetation condition is one of the aspects that is considered in closure, rehabilitation and offsets planning. These aspects are described in their respective sections.

Cumulative impacts to the vast majority of flora species of conservation significance are not considered to be significant; however, impacts to known records of Synostemon hamersleyensis, are considered to have potential to be significantly impacted from the Strategic Proposal without mitigation.</td><td>The Land and Biodiversity Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's regional management approach and standard business management practices. Examples include:
Avoidance or minimisation through informed design by avoiding or minimising clearing habitat for conservation significant species, by undertaking baseline and targeted surveys and where practicable altering mine plans to avoid significant habitats.
Implement regional state offset initiative or project-specific offset initiatives where required to achieve the flora and vegetation objective, and undertake offset monitoring to ensure effectiveness.
Draft and implement management plans for key assets and significant species.
Establish performance criteria to maintain significant flora and vegetation or areas with ecological value.
Refer to the Water Management Toolkit and Rehabilitation and Decommissioning Toolkit for further management measures.</td></tr>
</table>

<table>
<tr><th colspan="2">Acceptability of Impact</th></tr>
<tr><td rowspan="2">The cumulative impact to the above Beard vegetation associations will result in a reduction of these associations, so that 94.2% and 81.5%, respectively, of the pre-European extent remains. Both of these vegetation associations occur outside of the Pilbara bioregion and are common and widespread in the Pilbara region.

None of the consolidated vegetation associations mapped on BHP Billiton Iron Ore tenure are located within formally recognised PECs or TECs. Given BHP Billiton Iron Ore's commitment to manage impacts to these areas in line with the key regional asset management, BHP Billiton Iron Ore considers that impacts to conservation-significant vegetation associations will be managed to an acceptable level.

Synostemon hamersleyensis has potential to be significantly impacted by the Strategic Proposal. This species has only recently been described (2015), and knowledge on the species occurrence and ecology is still evolving. Given that 50% of known records of Synostemon hamersleyensis may be impacted under the Full Conceptual Development Scenario, BHP Billiton Iron Ore recognises that this species will require considered management to meet the objectives for flora and vegetation. BHP Billiton Iron Ore will validate that the objectives for flora and vegetation can be met as part of any future Derived Proposal referral at a local and regional scale using updated baseline data and detailed mine planning and design. Given this validation process, BHP Billiton Iron Ore considers that impacts to this species will be managed to an acceptable level.</td><td>Potential Inherent Impact Rating:</td></tr>
<tr><td>Potential Residual Impac Rating (after mitigation):</td></tr>
</table>

EPA Environmental Factor – Terrestrial Fauna

EPA Objective – to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to terrestrial fauna from its activities to an acceptable level.

Potential Impacts	Management Approach
There is no regional dataset for vertebrate fauna habitat in the Pilbara, so landform and land system mapping has been used to assess the potential regional impact to vertebrate fauna habitats. The highest impact is to the Wannamunna Land System, with a predicted impact of 10.41%. The hardpan plains that comprise most (56%) of this land system are unlikely to support any breeding populations of conservation-significant species; although the mulga woodlands, which are not constrained to the Wannamunna Land System, do support a number of species (in particular birds and reptiles) that are largely restricted to this habitat type. Consolidated fauna habitat mapping within BHP Billiton Iron Ore tenure (including miscellaneous licences) provides detailed information on fauna habitats, and identifies those habitats that are at higher risk under implementation of the 30% or Full Conceptual Development Scenario, and therefore would be the focus of further investigation or management at the Derived Proposal stage. Those habitats identified to have the highest proportional impact under the Full Conceptual Development Scenarios were Drainage Area (30.5%), Gorge/Gully (30.4%), Minor Drainage Line (29.5%), Crest/Slope (28.4%), Mulga (27.9%) and Hardpan (26.5%). These habitats are found extensively outside BHP Billiton Iron Ore tenure. Five species of conservation significance were identified from the 2015 data to have more than 10% of their known records occurring within the Full Conceptual Development Scenario footprints. These were the Pilbara olive python (14.05%), ghost bat (22.29%), Pilbara flat-headed blind-snake (29.55%), Pilbara barking gecko (29.41%), and western pebble-mound mouse (33.72%). Suitable SRE fauna habitat within Full Conceptual Development Scenario footprint, was identified as medium and high risk areas. From this, potential priorities for future management were derived.	The Land and Biodiversity Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's regional management approach and standard business management practices. Examples include: • *Avoidance or minimisation through informed design* by avoiding or minimising clearing of habitat for conservation-significant species through undertaking baseline surveys and, where practicable, altering mine plans to avoid significant habitats. • Undertake *ecological asset monitoring* where appropriate. • Draft and implement *management plans* for key assets and significant species. • Establish *performance criteria* to maintain terrestrial fauna habitat values. • *Progressive rehabilitation* of altered landforms, where possible, in line with the Rehabilitation and Decommissioning Management toolkit using provenance species and creating fauna habitat where possible. • Undertake appropriate *putrescible waste management* to avoid attracting and maintaining populations of introduced species. • Undertake *employee awareness programs*, e.g. inductions, toolbox meetings highlighting fauna issues. • Implement the *fire response procedure* to ensure that the Strategic Proposal does not increase fire risk. Refer to the Water Management Toolkit, Air Management Toolkit and Rehabilitation and Decommissioning Toolkit for further management measures.

Acceptability of Impact		
BHP Billiton Iron Ore recognises that without effective mitigation, there are potential significant impacts to some terrestrial fauna habitat types and known species locations. BHP Billiton Iron Ore considers that impacts to fauna habitat can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Land and Biodiversity Management Toolkit. Validation of habitat extent and presence of conservation significant species as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for fauna, and also for areas of habitat that are key assets or support conservation –significant species.	**Potential Inherent Impact Rating:**	
	Potential Residual Impact Rating ***(after mitigation)*****:**	

EPA Environmental Factor –Subterranean Fauna

EPA Objective – to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to terrestrial fauna from its activities to an acceptable level.

Potential Impacts	Management Approach
Stygofauna: Stygofauna habitat was considered to be of high prospectivity if depth to groundwater was less than 40 m. Strategic Proposal tenure in which both high prospectivity habitats and medium to high groundwater change potential occur are predicted to be Tandanya, Mudlark, Jinidi, Newman, Jimblebar, Carramulla, Coondiner, Mindy and Marillana. 60% of stygofauna species in the Pilbara have locally restricted distributions (known from single sub basins, such as the middle Fortescue), and Halse et al. (2014) suggested the median range of such species is less than 700 km^2. Thus, it is likely that about 30% of stygofauna species have ranges that are small enough to be threatened by impacts approaching 30 km in linear extent if the species' distribution and impacts coincide. In most situations, the factors controlling species' distributions and impacts will be different so that relatively few species distributions are likely to be completely encompassed by impacted areas. **Troglofauna:** Areas of likely troglofauna occurrence were determined using an investigative method based on topography. All areas with a slope greater than 11.6° were considered to contain valley flanks, mesas or other features likely to support troglofauna. The mapping highlights the Hamersley Range as being likely to contain the richest troglofauna communities in the Pilbara, which existing information suggests is correct. Almost all BHP Billiton Iron Ore tenure proposed as future mining hubs overlaps with areas that are predicted to be of high prospectivity for troglofauna. The exceptions are Jimblebar, Caramulla, Ophthalmia/Prairie Downs and Roy Hill.	The Land and Biodiversity Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's regional management approach and standard business management practices. Examples include: • *Avoidance through informed design* by minimising clearing to the smallest area possible and placing waste in-pit where practicable. • *Avoidance* or *minimisation through informed design* by avoiding or minimising removal of habitat for subterranean fauna, by undertaking *baseline surveys* and where practicable altering mine plans to avoid significant habitats. • Avoid unauthorised clearing (or excavation) through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • Undertake appropriate *groundwater management* to avoid significant impacts to areas with high subterranean fauna value. • Undertake *ecological asset monitoring* where appropriate for areas with high subterranean fauna values.

Acceptability of Impact

BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact subterranean habitat of high prospectivity through mining and groundwater drawdown. BHP Billiton Iron Ore considers that impacts to fauna habitat can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Land and Biodiversity Management Toolkit. Validation of habitat extent and requirements of subterranean fauna as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for subterranean fauna once detailed mine design and planning is determined.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)*:

EPA Environmental Factor – Terrestrial Environmental Quality and Landforms

EPA Objectives:

- **Terrestrial Environmental Quality** – to maintain the quality of land and soils so that the environmental values, both ecological and social, are protected.
- **Landforms** – to maintain the variety, integrity, ecological functions and environmental values of landforms.

BHP Billiton Iron Ore Objectives:

- **Terrestrial Environmental Quality** – BHP Billiton Iron Ore shall mitigate risks to terrestrial environmental quality from its activities to an acceptable level.
- **Landforms** – BHP Billiton Iron Ore shall mitigate risks to landforms from its activities to an acceptable level.

Potential Impacts	Management Approach
The Project Definition Boundary consists of a range of common landforms generally classified as hills and ranges and other elevated areas or plains. Impacts to landforms and landscapes at the regional level were considered to be low: • Between 0% and 1.34% reduction in the area of landscape units. All retain more than 96% of their pre-European extents. • Between 0.080% and 0.771% reduction in the area of landform types. All retain more than 98% of their pre-European extents. • Between 0% and 8.05% reduction in the area of land systems. All retain more than 90% of their pre-European extents. Impacts to terrestrial environmental quality were identified as potentially stemming from AMD and erosion. The study identified potential risk areas and showed that the risks are still relatively low compared to other regions and the rest of the state. Successful AMD and erosion management have been a substantial part of the management of existing operations in the region. As management is site-specific, tailored to unique site geomorphologies and geochemistries, detailed management of potential AMD and erosion risk will be addressed prior to any mining operation commencing after being informed by site-specific baseline assessments.	Key mitigation tools for landforms and terrestrial environmental quality are presented in Rehabilitation and Decommissioning.

Acceptability of Impact	
BHP Billiton Iron Ore considers potential impacts to landform extent to be acceptable, given that the extent of landscape units, landform types and land systems will remain high relative to their pre-European extents. BHP Billiton Iron Ore considers that impacts to terrestrial environmental quality can be managed to an acceptable level through normal business management practices or though targeted management measures identified in Rehabilitation and Decommissioning toolkit. Validation as part of Derived Proposal referrals will demonstrate that BHP Billiton Iron Ore can meet the objectives for landforms and terrestrial environmental quality once detailed mine design and planning is determined.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Hydrological Processes and Inland Waters Environmental Quality

EPA Objectives:

- **Hydrological Processes** – to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.
- **Inland Waters** – Environmental Quality: to maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

BHP Billiton Iron Ore Objectives:

- **Hydrological Processes** – BHP Billiton Iron Ore shall mitigate risks to hydrological processes from its activities to an acceptable level.
- **Inland Waters Environmental Quality** – BHP Billiton Iron Ore shall mitigate risks to inland waters environmental quality from its activities to an acceptable level.

Potential Impacts	Management Approach
There is potential for groundwater drawdown and reduction in surface water availability for BHP Billiton Iron Ore's Full Conceptual Development Scenario without mitigation in place. Without mitigation, key areas of surface water change for the Full Conceptual Development Scenario include the northern flank of the Fortescue River Valley, lower Weeli Wolli Creek, catchment areas surrounding Coondewanna Flats, and drainages that contribute flows to Ethel Gorge. Without mitigation, the areas of potential change in EHUs related to groundwater drawdown are most apparent in the central Pilbara, Fortescue Marsh, and Marillana Creek regions and Weeli Wolli Creek. Change potential for key environmental assets is summarised below: • Coondewanna Flats, Ethel Gorge, Fortescue Marsh and Weeli Wolli Spring have moderate to high level potential impacts without mitigation in place. • Freshwater Claypans of the Fortescue Marsh and Karijini National Park have no to low or moderate change potential without mitigation in place.	The Water Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's regional management approach and standard business management practices. Examples include: • Undertake *controlled dewatering* to ensure that groundwater drawdown is minimised as far as practicable while meeting operational needs. • Undertake *ecological asset monitoring* where appropriate for ecological receptors in line key assets and significant species management as above. • Undertake *managed aquifer recharge* or *controlled surface water discharge* where appropriate to mitigate groundwater drawdown. • Undertake groundwater monitoring where appropriate to detect changes in groundwater quality to trigger an effective management response. • *Avoidance* or *minimisation through informed design* by avoiding or minimising clearing of significant flora and vegetation.

Acceptability of Impact	
BHP Billiton Iron Ore recognises that the Strategic Proposal has potential to impact certain parts of the landscape through impacts to surface water as described above if appropriate mitigation is not implemented. The modelled outputs highlight the mitigation considerations for EHUs. BHP Billiton Iron Ore considers that impacts to groundwater can be managed to an acceptable level through normal business management practices or though targeted management measures identified in the Water Management Toolkit. BHP Billiton Iron Ore has a proven track record of implementing water management measures to manage impacts to an acceptable level.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Heritage

EPA Objective – to ensure that historical and cultural associations are not adversely affected.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to heritage from its activities to an acceptable level.

Potential Impacts	Management Approach
Aboriginal heritage is managed and protected in compliance with the Aboriginal Heritage Act. Large-scale archaeological and ethnographic surveys have been undertaken to identify places of cultural significance. These surveys are undertaken with the relevant Native Title groups of the area. Approximately 55% of the Full Conceptual Development Scenario area has been archaeologically surveyed with all identified heritage sites (archaeological and ethnographic) managed by BHP Billiton Iron Ore's Heritage and GIS teams. The potential to disturb European heritage places is considered low.	The Heritage Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's standard business management practices. Examples include: • *Avoidance through informed design* by avoiding known sites and engaging with Native Title claimants to determine heritage values. • *Avoidance* or *minimisation through informed design* by demarcation of known sites of significance. • *Avoidance* through unauthorised clearing, access or activities through implementation of the *spatial on-site disturbance compliance tool* (i.e., PEAHR procedure). • *Minimise* potential impact through consultation and via the development and application of a Cultural Materials Management Plan. • *Minimise* potential impact by monitoring cultural heritage sites • *Minimise* impact via the establishment of Native Title Agreements

Acceptability of Impact

BHP Billiton Iron Ore will continue to engage with Native Title Groups through targeted consultation and via administration of heritage Agreements, and therefore any potential impacts to heritage values are considered to meet the EPA's factor objective through business as usual management standards, with a high level of certainty that acceptable outcomes will be achieved.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Amenity (visual and noise)

EPA Objective – to ensure that impacts to amenity are reduced as low as reasonably practicable.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to amenity from its activities to an acceptable level.

Potential Impacts	Management Approach
The visual and noise assessments demonstrate that impacts at the regional scale are predicted to be low, both from BHP Billiton Iron Ore 30% and Full Conceptual Development Scenarios and cumulatively. Impacts to visual amenity are likely to be restricted to several areas: • Newman, surrounding settlements and Ophthalmia Dam; • Weeli Wolli Creek system; • Great Northern Highway; and • Mount Meharry (Karijini National Park). Cumulative noise modelling identified two sensitive receptors where noise criteria were exceeded: Mount Meharry and Weeli Wolli Creek. The predicted exceedances were based on cumulative impacts from third-party developments, business-as-usual management and conservative assumptions. It is considered that noise can be managed to an acceptable level by application of additional mitigation, where relevant.	Implement the Amenity Management toolkit in accordance with BHP Billiton Iron Ore's regional management approach and standard business management. Examples include: • Avoidance through informed design by minimising clearing to the smallest area possible. • Avoidance or minimisation through informed design by locating mining and mining-related activities away from sensitive receptor locations. • Minimise visual impact via visual screening methods, which may include screening structures, vegetation or engineering controls. • Rehabilitate cleared areas, progressively where possible.

Acceptability of Impact

Amenity (visual amenity and noise) was not considered a key environmental factor when the EPA provided its determination on the ESD; however, in recognition of potential societal impacts from its mining operations, BHP Billiton Iron Ore has assessed and discussed this factor in the PERSP. BHP Billiton Iron Ore has applied the significance framework detailed in Environmental Guideline 9 (EPA 2015b) during the assessment of these environmental factors and has found that the residual impact to visual amenity and noise amenity is anticipated to meet the EPA's factor objective with a high level of certainty that acceptable outcomes will be achieved.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Air Quality and Atmospheric Gases

EPA Objective – to maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.

BHP Billiton Iron Ore Objective – BHP Billiton Iron Ore shall mitigate risks to air quality and atmospheric gases from its activities to an acceptable level.

Potential Impacts	Management Approach
Given the nature of the environmental context and the relatively remote nature of the proposed operations, the strategic assessment focused on particulate (or dust) emissions to air and on greenhouse gases. For the Full Conceptual Development Scenario, with Leading Controls at BHP Billiton Iron Ore operations and Standard Controls at third-party operations, predicted PM_{10} concentrations are above the Air NEPM standard at eight sensitive receptors with Leading Controls in place; with Marillana Homestead and Wirrilimarra community area being the only two sensitive receptors to be permanently occupied. Marillana Homestead was identified as the only permanently occupied sensitive receptor not to meet the Kwinana EPP TSP limit with Leading Controls at BHP Billiton Iron Ore operations. It should be noted that the Full Conceptual Development Scenario is conservative in that it assumes all sites are operating concurrently and at full production. As such, the modelled outcomes will overestimate likely impacts. It is also noted that the predicted exceedances of the PM_{10} standard and TSP criteria at Marillana Homestead and Wirrilimarra community area appear to be strongly influenced by third-party operations, which are outside of BHP Billiton Iron Ore's control. BHP Billiton Iron Ore's cumulative contribution to these sensitive receptors is low, when Leading Controls are applied. Predicted GHG contributions at an Australian and Western Australian level are 0.8% and 6.2% respectively.	The Air Emissions Management toolkit will be implemented in accordance with BHP Billiton Iron Ore's regional management approach and standard business management practices for construction and operational phases. Examples include: • *Avoidance through informed design* by minimising clearing to the smallest area possible. • *Avoidance or minimisation through informed design* by locating dust-generating activities away from sensitive receptor locations. • *Minimise dust generation* by ore and waste moisture management. • *Minimise dust generation* by reducing the exposed ore surface area or by implementing dust control measures such as barriers. • *Rehabilitate* cleared areas, *progressively* where possible, thus minimising surface area with potential for exposure as dust. • *Monitor* ambient air dust levels and report and manage as required. The management of particulate emissions is an important operational focus, with emissions managed using standard business management practices for construction and operational phases. The Air Quality Assessment (Appendix 9) demonstrates the improvement possible with management intervention.

Acceptability of Impact

At a regional level, the model shows the Strategic Proposal, with mitigation, can maintain air quality for the protection of human health and amenity. This assessment has demonstrated the improvement possible with mitigation of dust impacts on the broader Newman area. Furthermore, the Strategic Proposal assessment has considered controls in the broad sense; and it is reasonable to assume that, as a regional management approach is applied to Derived Proposals, there will be greater opportunity to implement tailored actions to manage emissions effectively. The assessment completed for the Strategic Proposal shows that, with the implementation of management measures, the EPA objective for Air Quality and Atmospheric Gases can be met. BHP Billiton Iron Ore will implement a combination of targeted management and controls, in addition to business-as-usual management, as required to manage Air Quality and Atmospheric Gases to an acceptable level.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Rehabilitation and Decommissioning

EPA Objectives – To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.

BHP Billiton Iron Ore Objectives – BHP Billiton Iron Ore shall manage its activities for the creation of safe, stable, non-polluting and sustainable landscapes so as to reduce risks to an acceptable level.

Potential Impacts	Management Approach
Without mitigation, the impacts associated with the Strategic Proposal will affect BHP Billiton Iron Ore's ability to meet its objective for Rehabilitation and Decommissioning. Rehabilitation of OSAs, associated infrastructure and rail is anticipated to reach a Good vegetation condition or better over time. The Rehabilitation and Decommissioning Management toolkit will be applied to minimise the footprint, where practicable, and to adopt the most effective rehabilitation method available for the infrastructure type at the time. For the purpose of the assessment, mine voids are considered unlikely to achieve a better vegetation condition than Degraded; therefore, BHP Billiton's residual impact, once rehabilitation and decommissioning are complete, is conceptually 50,316 ha. With adaptive management and advances in knowledge, mine void rehabilitation success may improve in the future. BHP Billiton Iron Ore will quantify the footprint area subject to residual impact at the time of any Derived Proposal submission.	• Plan for appropriate *OSA location and design*. • Develop appropriate *completion criteria* for landforms. • Conduct *climate change sensitivity assessment* where appropriate to ensure that final landforms are designed to withstand climate change. • Minimise impacts from clearing by *growth media management* to enable rehabilitation success. • Minimise presence of mine voids and pit lakes upon closure through mine planning, closure planning and *informed design*. • Minimise of impacts to water by *surface water drainage control* and through *pit lake management*. • *Minimise disturbance footprint through informed design.* • Undertake *progressive rehabilitation* where possible, and *rehabilitation monitoring* to determine rehabilitation success. • Undertake *geochemical waste characterisation* to inform final landform design. • Minimisation of impacts to soils and water through *AMD risk assessment*, and *PAF and unstable material avoidance* and/or *management*. Refer to the Land and Biodiversity Management Toolkit and the Water Management Toolkit for further management measures.

Acceptability of Impact

Effective rehabilitation of vegetation, to at least Good or better quality condition, is considered to be achieved for at least 50% of the Full Conceptual Development Scenario footprint within 15 years of cessation of activities. Given the Company's historical performance with rehabilitation and decommissioning, application of the management processes, a regional approach to management and preparation of mine closure plans, it is concluded that potential impacts are considered to meet EPA's factor objective through targeted management in addition to business-as-usual management. There is a moderate to high level of certainty that an acceptable outcome will be achieved.	**Potential Inherent Impact Rating:** **Potential Residual Impact Rating** *(after mitigation)***:**

EPA Environmental Factor – Offsets

EPA Objectives – to counterbalance any significant residual environmental impacts or uncertainty through the application of offsets

BHP Billiton Iron Ore Objectives – BHP Billiton Iron Ore shall counterbalance any significant residual environmental impacts or uncertainty through the application of offsets

Management Approach

The Strategic Proposal enables consideration of environmental offsets as part of a long-term regional approach and provides a unique opportunity for BHP Billiton Iron Ore to deliver offsets that have strategic outcomes, are coordinated and are developed to address regional- or landscape-scale residual impacts and threatening processes. Where significant residual environmental impacts are identified for a Derived Proposal, BHP Billiton Iron Ore will provide either a regional offset at the Strategic Proposal level or a project-specific environmental offset.

Based on the area of potential direct impact, approximately 98,500 ha of disturbance will potentially occur due to by the BHP Billiton Iron Ore's Full Conceptual Development Scenario. Based on current rehabilitation practices and assumptions associated with vegetation rehabilitation ability (for example, no rehabilitation of pit areas), the residual impact of the Full Development Scenario is 50,316 ha.

The success of rehabilitation as a mitigation measure will be determined by a number of factors. For the purpose of estimating the quantum of residual impact, it has been assumed that rehabilitation will have achieved successful mitigation if vegetation of Good or better quality is establish that it is consistent with the final land use as defined in the mine closure plan. BHP Billiton Iron Ore believes that this level of success can be achieved on areas disturbed for OSAs, rail, and associated infrastructure (but not pits). On this basis, the potential scale of the residual impact from development of the BHP Billiton Iron Ore Full Conceptual Development Scenario is approximately 50,316 ha.

This figure and the scale of each future proposal offset will be validated and set at the Derived Proposal stage. The acceptance of rehabilitation as a mitigation measure will require ongoing verification of rehabilitation success.

9.3 Uncertainty Related to the Strategic Proposal

This section describes the nature of uncertainty related to the Strategic Proposal and discusses whether or not this uncertainty should be considered material to the assessment. There is a distinction between scientific uncertainty and uncertainty due to an assessment being based on inadequate or insufficient information. Scientific uncertainty is not always avoidable; however, if a species is little known, then the precautionary principle can be applied to ensure that measures to prevent degradation of the environment where there are threats of serious or irreversible environmental damage are not postponed and to ensure that the EPA objectives are met. BHP Billiton Iron Ore considers that the quantitative and qualitative foundations relied upon are appropriate for the Strategic Proposal, particularly in light of the nature and scale of a regional approach to impact assessment.

Inputs to the impact assessment are outlined in Chapter 7. These inputs are a combination of analytical (quantitative) and factual (qualitative) 'tools' that have allowed BHP Billiton Iron Ore to undertake an informed, comprehensive and broad-scale assessment of potential impacts to environmental factors as a result of the implementation of the Strategic Proposal. Any one of these inputs, on its own, would not have been able to provide the breadth of information required to assess potential impacts. BHP Billiton Iron Ore recognises that there are uncertainties associated with and documented in each of the impact assessment's inputs. However, the breadth of inputs used has resulted in a technically robust and appropriate impact assessment that has been undertaken by suitably qualified, experienced personnel with the ability to synthesise and interpret the range of information available to them.

Certain assumptions have been made for the purpose of this PERSP to be in a position to assess impacts at a regional scale rather than on a project-by-project basis. This is particularly relevant for disturbance boundary assumptions, where exact disturbance footprints (e.g. for pits and overburden storage areas) were estimated rather than accurately defined, because project specifics are not yet known. Estimations were based on BHP Billiton Iron Ore's working knowledge of clearing requirements, mine planning and design. While BHP Billiton Iron Ore recognises that this may introduce a degree of inaccuracy, the information is used in the broader context of the Pilbara landscape; it is not going to be used to estimate impacts at the local scale. Similarly, rail alignments were indicative only; again, this is not considered to be a significant limitation in the context of a regional strategic assessment. It is important to remember that, for a regional assessment, a more broad-scale approach is both necessary and appropriate; site-specific data are not the focus at the regional scale of a strategic assessment: they are incorporated at the local level when design detail is known at the Derived Proposal stage.

Technical uncertainty as it applies to the cumulative impacts assessments is discussed in Chapter 8 and detailed in the technical appendices.