APPENDIX 1 - SURFACE WATER ASSESSMENT

Groundwater Resource Management (2018) *Report on Pilgangoora Lithium-Tantalum Project 5 MTPA Definitive Feasibility Study Surface Water Management.* Prepared for Pilbara Minerals Limited.

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REPORT ON

PILGANGOORA LITHIUM-TANTALUM PROJECT

5 MTPA DEFINITIVE FEASIBILITY STUDY

SURFACE WATER MANAGEMENT

Prepared for

Pilbara Minerals Limited

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EXECUTIVE SUMMARY

Pilbara Minerals Limited (PLS) have initiated a Definitive Feasibility Study (DFS) to investigate the application of a 5 Mtpa mining rate at their Pilgangoora Lithium-Tantalum Project (the Project) in the Pilbara Region of Western Australia. PLS has commissioned Groundwater Resource Management Pty Ltd (GRM) to complete the hydrogeological and hydrological components of the DFS.

This report presents the findings from the DFS Surface Water Management study which has built on the results of the hydro-meteorological desktop study and surface water management study completed previously as part of the 2 Mtpa Definitive Feasibility Study (DFS). Where findings from the previous 2 Mtpa DFS are shared with the current 5 Mtpa DFS they have been repeated in this report, while significant differences have been highlighted. The following key findings are made:

- The regional climate is one of extremes and droughts and major floods can occur in the same area within a few years of each other. The climate in this region is highly variable, both spatially and temporally, and this can make hydrologic analysis and the design of water management measures difficult.

- The Project is located entirely within the eastern portion of the Turner River catchment (part of the Port Hedland Coast Basin) immediately to the west of the regional watershed with the Strelley River (part of the De Grey River Basin). The Project facilities will be developed within the following six existing catchment areas (named in a north to south direction):

  - Turner River East Creek Catchment = 28.5 km^2;
  - Northern Creek Catchment Area = 26.4 km^2;
  - Houston Creek Catchment Area = 17.6 km^2;
  - Pilgangoora Creek Catchment = 18.1 km^2;
  - Southern Creek Catchment Area = 18.8 km^2; and,
  - Chinnamon Creek = 287.5 km^2 (368.5 km^2 including Northern, Houston, Pilgangoora and Southern Creek catchments which report to Chinnamon Creek).

  All of these catchments ultimately report to the Turner River downstream (west) of the Project site.

- A delineation of existing pre-mining and proposed end-of-mining catchments and associated runoff volume estimates indicate that an overall runoff volume loss of approximately 0.4% will occur as a result of development of the 5 Mtpa Project facilities. This loss will be due to runoff being generated in-pit, diverted in-pit or becoming “trapped” in sub-catchments with no obvious outlet. The relatively small Houston Creek catchment will be the most greatly affected with an approximately 6% loss of runoff volume downstream, while the volume of runoff reporting from the Pilgangoora Creek catchment will reduce by about 4% post-mining. There will only be negligible (<1%) changes in the off-site post-mining runoff volumes from the Turner River East, Northern, Southern and Chinnamon Creek catchments.

- Given its location within a semi-arid region with mean annual rainfalls in the order of 325 mm, all of the on-site creeks and drainages are ephemeral in nature and only convey flow following periods of significant rainfall. Significant short duration rainfall

events occur during the summer months when the potential exposure to Tropical Cyclones and other low-pressure related events is greatest.

Historically these events have delivered daily rainfall totals in excess of 350 mm i.e. maximum daily rainfall exceeds mean annual rainfall. Such events yield high runoff rates and could lead to loss or damage to Project assets if appropriate management measures are not in place.

- Estimates of the Probable Maximum Precipitation (PMP) and resulting Probable Maximum Flood (PMF) were completed as part of the hydrological assessment and were subsequently adopted for the design of post-mining water management measures. These show that PMP rainfall depths of approximately 500, 1,250 and 2,250 mm could occur at the site over 1, 24 and 72 hour periods respectively and that peak PMF flows in the order of 880 m^3/s could be generated by the Pilgangoora Creek catchment upstream of the proposed Central Pit (commensurate values for the 100 year ARI event are 93, 339 and 416 mm and 164 m^3/s).

- Given the proximity of the regional watershed divide, about 2 km to the east, the catchment areas upstream of the Project facilities will be relatively limited. In addition, the pit crests will be established within a range of north-south trending hills of up to about 80 m relief, with pit crests daylighting mostly at elevated locations. For these reasons and the fact that primary flood protection will be offered to the proposed pits by the construction of WRD's along the eastern/upstream side of the proposed pits, the majority of the pit crests will require minimal flood protection measures.

- It is likely only where pit crests and other facilities are established in valleys between the existing hills that they are considered to be at potential risk from flooding. This is particularly the case for the southern crest of the proposed Central Pit and Stage 2 TMF embankment which will both intersect Pilgangoora Creek and will require diversion channels to be constructed.

- The Central Pit/Pilgangoora Creek diversion will be constructed in two stages, namely: ***Diversion Stage 1*** – will be required between start-up and Year 5 in order to protect the southern limit of the Central Stage 1 to 4 Pit, and ***Diversion Stage 2*** – will be required between Year 10 and Year 15 to protect the Central Stage 5 Pit to the southwest. The preliminary design of the diversion has been conservatively based on conveying the 100 year ARI flood event with freeboard and the PMF event with zero freeboard.

  The Stage 1 diversion will comprise an approximately 553 m long channel with a 25 m base width and 2H:1V (26.6°) sideslopes. The channel will be aligned between the ultimate Central and Southern Pit crests and will slope at a gradient of approximately 0.71% to match existing upstream and downstream creek elevations. Flood bunds with a 5 m wide crest will be constructed along both sides of the diversion to a minimum height of 6 m above the channel invert. Approximately 45,000 m^3 of cut and some 74,000 m^3 of fill will be required to construct the Stage 1 diversion. Assuming that all material excavated from the channel can be re-used to construct the flood bunds, a further 29,000 m^3 will need to be imported from other on-site sources to meet the shortfall.

- The Stage 2 diversion will comprise an approximately 508 m long channel with a 25 m base width and 2H:1V (26.6°) sideslopes. The channel will be aligned around the Central Stage 5 Pit crest and will slope at a gradient of about 0.44% to match the existing upstream creek elevation and tie-in with the Stage 1 diversion channel. Flood bunds with a 5 m wide crest will be constructed along both sides of the diversion to a minimum height of 6 m above the channel invert. Approximately 64,000 m^3 of cut and some 34,000 m^3 of fill will be required to construct the Stage 2

diversion. Assuming that the fill requirement can be met from the excavated material, there will be in the order of 30,000 m^3 of surplus excavated material from the channel cutting to be dumped within the proposed WRD's and/or TMF embankment.

- The TMF Stage 2/Pilgangoora Creek diversion will be required between Year 5 and Year 9 and comprise a roughly 2,190 m long channel with a 15 m base width and 0.58H:1V (60°) cut batter slopes and compacted earthfill flood bunds with a 5 m crest width and 2H:1V (26.6°) slopes along both sides. The flood bunds should be constructed to a height some 13.5 m above the channel invert in order to convey the peak of the PMP/PMF event. The channel will be aligned along the southern and western toe of the ultimate TMF embankment and will slope at a gradient of about 0.27% to match existing creek elevations.

  Approximately 354,000 m^3 of cut and some 612,000 m^3 of fill will be required to construct the diversion. Assuming that the bulk of the fill material required to construct the earthfill flood berms there will be a deficit of some 258,000 m^3 of material that will need to be imported from elsewhere on-site.

- The West WRD from years 3/4 prevents runoff from the East WRD and an approximately 25 ha catchment to north of the Eastern Pit from reporting off-site towards the west and essentially forms a trapped catchment. If this area is not allowed an outlet, runoff could report to the Eastern Pit. It is proposed to provide a drain for this area under the West WRD, discharging to existing drainage line to the west. The drain would be constructed by excavating a channel along the drainage alignment, backfilling with coarse competent rock material and covering with geotextile prior to construction of the waste landform.

- Surface water management measures required for start-up of operations are considered to be relatively modest. These will likely be limited to temporary flood protection berms, diversions and sedimentation ponds for clearing and stripping activities and culverted crossings below haul roads and Airfield. The preliminary design given here needs to be further developed as part of the detailed design process.

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Figure 1 Pilgangoora Project Location & DoW Regional Catchment Boundaries

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Dwg. No. -D02	5 Mtpa DFS Local Catchment Delineation & Water Management Plan
Dwg. No. -D03	5 Mtpa DFS Pilgangoora Mining Area Year 0 Facility Plan
Dwg. No. -D04	5 Mtpa DFS Pilgangoora Mining Area Year 5 Facility Plan
Dwg. No. -D05	5 Mtpa DFS Pilgangoora Mining Area Year 10 Facility Plan
Dwg. No. -D06	5 Mtpa DFS Pilgangoora Mining Area Year 15 Facility Plan
Dwg. No. -D07	5 Mtpa DFS Pilgangoora Mining Area Year 18 Facility Plan
Dwg. No. –D08	5 Mtpa DFS Central Pit/Pilgangoora Creek Stage 1 Diversion
Dwg. No. –D09	5 Mtpa DFS Central Pit/Pilgangoora Creek Stage 2 Diversion
Dwg. No. –D10	5 Mtpa DFS TMF Stage 2/Pilgangoora Creek Diversion

APPENDICES

Appendix A Intensity Frequency Duration Relationship & PMP/PMF Estimate for Pilgangoora Project Site

1.0 INTRODUCTION

1.1 Background

The Pilgangoora Lithium-Tantalum Project (the Project) is located 150 km south-east of Port Hedland in the Pilbara region of Western Australia. Pilbara Minerals Limited (PLS) has initiated a Definitive Feasibility Study (DFS) for the Project to assess the economic viability of a 5 Mtpa mining operation, processing plant and associated infrastructure. PLS has engaged Groundwater Resource Management Pty Ltd (GRM) to undertake the hydrogeological and hydrological components of the DFS.

This report presents the findings from the DFS Surface Water Management study which has built on the results of the hydro-meteorological desktop study and surface water management study completed previously as part of the 2 Mtpa Definitive Feasibility Study (DFS). Where findings from the previous 2 Mtpa DFS are shared with the current 5 Mtpa DFS they have been repeated in this report, while significant differences have been highlighted.

The 2 Mtpa DFS Hydro-meteorological Study completed in early 2016[1] found that:

- The regional climate is one of extremes and droughts and major floods can occur in the same area within a few years of each other. The climate in this region is highly variable, both spatially and temporally, and this can make hydrologic analysis and the design of water management measures difficult.

- The Project is located in the eastern portion of the Turner River catchment (part of the Port Hedland Coast Basin) immediately to the west of the watershed with the Strelley River (part of the De Grey River Basin). Although situated in a semi-arid region with mean annual rainfalls in the order of 325 mm, significant short duration rainfall events can occur during the summer months when Tropical Cyclones and related low-pressure systems cross the Pilbara coast. Such events have delivered daily rainfall totals in excess of 300 mm locally.

- The Indee station, located some 43 km northwest of the proposed site, remains open and has 105 years of relatively high quality daily data. The Indee station has mean and median annual rainfalls of 326 mm and 288 mm respectively and is recommended for use where relevant in the design of Project infrastructure.

- Tropical cyclones bring heavy rains to the Pilbara region and although erratic in nature, occur relatively frequently and must therefore be considered in the design of infrastructure and surface water management measures. An analysis of cyclone data for the last 100 years shows that, on average, one cyclone will pass within 200 km of the Project every one to two years. On average, approximately once every five years a cyclone will pass within 100 km of the Project.

- Locally the wettest day on record occurred on 29 March 1988 when 354 mm was recorded at Indee, some 43 km northwest of the site. This rainfall was not attributed to a known tropical cyclone, but was obviously related to a very significant tropical low or depression event as it had an Average Recurrence Interval (ARI) in the order of 120 to 130 years. The second and third wettest days recorded locally of 281 mm (recorded at Strelley on 24 March 1942) and 275 mm (recorded at Indee on 4 February 1938) were both as a result of unnamed tropical cyclones.

[1] Groundwater Resource Management "*Hydro-Meteorological Desktop Study, Pilgangoora Lithium-Tantalum Project"*, Ref. J160002-R01 Final, February 2016.

- Short duration rainfall intensities due to cyclones and other depression related events can be significant. Maximum six minute duration intensities in excess of 200 mm/hr have been recorded at Port Hedland Airport 80 km north of Pilgangoora.

- A point rainfall intensity-frequency-duration (IFD) relationship was developed for Pilgangoora using the updated data set produced by the Bureau of Meteorology (BoM) in 2013. In summary, the 100 Year ARI point rainfall intensities for 1, 3, 12, 24 and 72 hr duration events are 93.2, 47.4, 21.8, 14.1 and 5.8 mm/hr respectively (giving equivalent storm depths of some 93, 142, 261, 339 and 416 mm).

- Regional evaporation data indicates that Pilgangoora can expect a mean annual pan evaporation of some 3,373 mm i.e. some ten times greater than mean annual rainfall. It is expected that approximately 65% to 70% of this amount will evaporate from shallow freshwater ponds and dams on site.

- The closest flow gauging station is located on the Turner River at Pincunah approximately 21 km south-southwest of the Pilgangoora site. This station has an upstream catchment area of about 885 km^2 and remains open, having been commissioned in early 1985. Data for this station indicates that annual and monthly flows are highly variable with a several order of magnitude increase between minimum and maximum values. The Turner River median annual flow at Pincunah is in the order of 12,400 ML/year which represents an average annual runoff yield of less than 5%.

- All on-site creeks and drainages at the Project are ephemeral in nature, only flowing following significant rainfall events. However, flows will occur periodically during the wet season months from December to March, when the potential exposure to high intensity cyclonic or tropical depression related rainfall is greatest. Consequently, on occasion, flows may be high and may cause localised flooding if appropriate measures are not in place.

Subsequent to the 2 Mtpa DFS Hydro-meteorological Study, an estimate of the Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) at the Project site was completed[2] (refer to Appendix A). These estimates show that PMP rainfall depths of approximately 500, 1,250 and 2,250 mm could occur at the site over 1, 24 and 72 hour periods respectively and that peak PMF flows in the order of 880 m^3/s could be generated by the Pilgangoora Creek catchment upstream of the proposed Central Pit (commensurate values for the 100 year ARI event are 93, 339 and 416 mm and 164 m^3/s). The potential impacts of a PMP/PMF event are discussed as relevant in this report.

This Surface Water Management report builds on the earlier hydro-meteorological study and combines the 5 Mtpa mine planning data to provide DFS engineering level designs of the works required to protect the proposed mine and associated facilities.

The 5 Mtpa DFS scope of work comprised the following surface water tasks:

- Floodwater management - hydrologic and hydraulic analyses.
- DFS level design of water management measures - described in the report and presented on preliminary engineering drawings.

The hydrologic and hydraulic calculations required as part of this study have been presented in the Appendices. The accompanying drawings have been completed to a level suitable for inclusion in the Project DFS and may form part of the future detailed engineering design of the Project.

[2] Groundwater Resource Management "*Pilgangoora Lithium-Tantalum Project – Probable Maximum Precipitation & Probable Maximum Flood Estimation*", Ref. J160002-M03, 13 January 2017.

1.2 Surface Water Management Objectives

The following three goals define the objectives for surface water management for the Pilgangoora Project:

Goal No 1 - Reduce Potential Risk of Loss of Life, Health Hazards or Property Damage

- provide protection for life, livelihood, and property;
- control the incidence of nuisance or damage related to flooding, poor drainage and sedimentation to an acceptable level; and,
- protect Project infrastructure.

Goal No 2 - Preserve the Environment

- minimise the potential Project impacts such as changes in the stream-flow regime, alteration of habitat, pollution or increased erosion and sedimentation;
- where feasible, maintain the shape and composition (geomorphology) of the natural watercourse geometry, natural biological indicator conditions and flow conditions;
- employ protection measures to prevent adverse hydrological and water quality impacts for all recognised watercourses within the site limits;
- promote sound development that respects the natural environment; and,
- rehabilitate any watercourses that are impacted as soon as practicable.

Goal No 3 - Conserve Social and Financial Resources

- treat water as a resource, ensuring that water management facilities are functional and integrate multi-use objectives where possible;
- provide a system of infrastructure that enhances site personnel convenience and safety, and allows development to proceed according to the mine plan;
- sustain future mine development, support orderly and managed development of resources and integration of land uses within the site limits;
- use best management water and sediment practices where feasible; and,
- encourage economic design of drainage systems.

These objectives are intended to ensure a consistent approach to:

- planning and analyses required for surface water management;
- constructing new operational phase surface water management works; and,
- installing future closure phase surface water management works.

The site visit findings are presented in the following section while a hydrological assessment of the local catchment areas is presented in Section 3.0 and the design philosophy for floodwater and surface water management measures is presented in Section 4.0. Preliminary engineering designs for those measures are then presented in Section 5.0.

2.0 HYDROLOGICAL ASSESSMENT

2.1 Catchment Delineation & Runoff Volume Estimation

2.1.1 Project Hydrological Setting

The Project site is located entirely within the Turner River catchment immediately to the west of the regional watershed divide with the Strelley River as shown in Figure 1. Both the Turner and Strelley Rivers are significant river systems, each draining total catchment areas of some 4,800 and 2,800 km^2 respectively. The Turner River catchment forms the easternmost part of the Department of Water and Environmental Regulation's (DWER's) designated Port Hedland Coast Basin (No. 709), while the Strelley River catchment forms the westernmost part of the De Grey River Basin (No. 710).

As described in the previous Stage 1 Hydro-meteorological Report, there are several relatively minor creeks or watercourses in the vicinity of the Project including Pilgangoora Creek, Houston Creek, Chinnamon Creek, two unnamed watercourses to the north and south of Pilgangoora Creek (referred to as Northern and Southern Creeks) and several creeks within the headwaters of the Turner River East (referred to as Turner River East Creek). The catchment areas for these creeks are shown on Drawing –D01.

The headwaters of the Turner River East rise at the northernmost part of the Project site and drain in a northerly direction before forming the river proper about 15 km to the north of the site. The Turner River East joins with the Turner River at a location about 55 km northwest of the Project site and continues in a northerly direction for a further 35 km or so before discharging into the Indian Ocean via marshlands located some 10 km west of Port Hedland.

Northern, Houston, Pilgangoora, Southern and Chinnamon Creeks drain in a roughly east to west direction across the Project site. The smaller Pilgangoora and Houston Creeks discharge into Northern Creek which in turn reports to Southern Creek before emptying into Chinnamon Creek about 14 km southwest of the Project site. Chinnamon Creek then continues in a north-easterly direction for approximately 25 km before discharging into the Turner River downstream of Chinnamon Pool. Chinnamon Creek has a total catchment area of about 368.5 km^2 upstream of its confluence with the Turner River.

All creeks and drainages in the vicinity of the Project site are typical of watercourses in the Pilbara in that they are ephemeral and highly variable with flows that can increase from zero to hundreds of cubic metres per second in a matter of hours as a result of tropical cyclones and other depression related events. Although none of the on-site creeks are gauged, it is understood that the majority of annual streamflow occurs during January, February and March, after which they usually recede and dry up by June or July. A few small, disconnected pools may remain throughout the year if recharged by groundwater and the level remains above the creek bed.

2.1.2 Pilgangoora Project Facilities

The proposed Project site may ultimately comprise six open pits (up to about 270 m deep), eight waste rock dumps (WRD), processing plant, tailings management facility (TMF) and associated haul roads, workshops, camp, airfield etc. The following preliminary findings were made regarding the hydrological setting of these proposed facilities:

Mining Area

The six proposed open pits and eight proposed WRD's will ultimately extend over a length of some 9.2 km in roughly north-south direction about 2 km to the west of the regional Turner/Strelley watershed divide. The pits and WRD's will be situated within a range of north-south trending hills of up to about 80 m relief.

The proposed pits comprise the following (named in a north to south direction along with their currently envisaged approximate start/completion years):

- Lynas Find Pit - Yr 3 to Yr 8 (non-continuously);
- Monster Pit - Yr 3 to Yr 17 (non-continuously);
- Eastern Pit - Yr 2 to Yr 16 (non-continuously);
- Central Pit - Yr 1 to Yr 18 (continuously);
- South Pit - Yr 10 to Yr 18 (non-continuously); and,
- South End Pit - Yr 11 to Yr 18 (continuously).

Waste from each proposed pit will be hauled to an adjacent WRD. Each pit will have a single, dedicated WRD of the same name, with the exception of Monster pit which will have three dedicated WRD's, namely; Monster Nos. 1, 2 and 3 WRD's, giving a total of eight WRD's.

All of the pits and WRD's will be developed within the following six existing catchment areas (named in a north to south direction) as shown in Drawing –D02:

- Turner River East Creek Catchment = 28.5 km^2;
- Northern Creek Catchment = 26.4 km^2;
- Houston Creek Catchment = 17.6 km^2;
- Pilgangoora Creek Catchment = 18.1 km^2;
- Southern Creek Catchment = 18.8 km^2; and,
- Chinnamon Creek = 287.5 km^2 (368.5 km^2 including Northern, Houston, Pilgangoora and Southern Creek catchments).

Given the proximity of the regional watershed divide, about 2 km to the east, the catchment areas upstream of the proposed mine facilities will be quite limited. In addition, the pit crests will be established within the existing hillsides and pit crests will daylight mostly at elevated locations. For these reasons and the fact that primary flood protection will be offered to the proposed pits by the construction of WRD's along the eastern/upstream side of the proposed pits, the majority of the pit crests will require minimal flood protection.

Therefore, it is likely only where pit crests are to be established in valleys between the existing hills that they are considered to be at potential risk from flooding. This is particularly the case for the southern crest of the proposed Central Pit which will intersect Pilgangoora Creek initially between start-up and Year 5 and again, further upstream, between Year 10 and Year 15, and will require a diversion channel to be constructed, likely in two separate stages (the preliminary engineering design of this diversion is presented in Section 4.0).

ROM/Plant/TMF Area

The proposed ROM/Plant/TMF area is located within the Pilgangoora Creek catchment on gently sloping ground to the west of the Central Pit and immediately west of the existing range of hills. The ROM will be constructed on an existing hillside at about 205 mAHD which is about 20 m above undisturbed ground levels along the western toe of the ROM. Crushed ore will be conveyed to the adjacent Plant located about 400 m south of the existing mine access road and immediately north of the proposed TMF. The TMF will be constructed in two stages as an integrated waste landform, where the tailings impoundment will be formed from compacted waste rock.

The ROM/Plant/TMF area is well situated from a surface water perspective as it has a very limited upstream catchment due to the existing range of hills to the east. There are a few minor drainage lines that cross the area in an east to west direction, but these should be easily managed with yard grading, minor diversion berms/windrows and roadside drainage.

The only surface water issue of concern within this area is the fact that the Stage 2 TMF (Cell 3) will intersect Pilgangoora Creek over a length of about 1.6 km. Given that deposition into Cell 3 is scheduled for Year 9, it will therefore be necessary to construct a diversion channel in advance. The diversion will be aligned around the southern and western toe of the ultimate TMF embankment to manage flows along Pilgangoora Creek (the preliminary engineering design of this diversion is presented in Section 4.0).

Workshops Area

The proposed workshops area is located within the Houston Creek catchment, north of the TMF and ROM pad. Ground elevations in the area are around 175 m AHD and land slope is toward the east from a low crest in the west. There are a number of small drainage lines and overland flow paths in the area, draining toward a larger drainage line from the south.

The workshops area is located in the area of a low crest so should not have much contributing catchment. However, there are drainage lines and shallow overland flow paths in the area. These flow paths should be considered when laying out the site and designing site infrastructure. Larger drainage lines should be avoided. Yard grading, minor diversion drains, berms/windrows and roadside drainage should be sufficient to manage overland flow paths.

Camp Area

The proposed Camp is located on the western tenement boundary, approximately 1 km west of the proposed Monster Pit and adjacent to the proposed Airfield (see below). There is little relief over the proposed Camp area other than a slight 2 to 3 m rise along its western edge and it is essentially flat with an existing ground elevations of about 180 to 181 mAHD.

The camp is situated within the Northern Creek catchment immediately north of the local catchment divide between it and Houston Creek to the south. Therefore it has a negligible upstream catchment area and is not considered to be at any significant risk of flooding. No special drainage measures are envisaged for the proposed Camp and yard and pad grading with roadside drainage should be sufficient.

Airfield Area

The proposed Airfield is aligned in a roughly north-south direction and is located towards the northern limit of the Project site to the west of the proposed Monster Pit and east of the proposed camp area. The Airfield is located entirely within the Northern Creek catchment. A runway currently exists at this location, but it is generally overgrown and considered to be

unusable in its current condition (a second, northwest-southeast oriented runway also exists at this location, but it is considered to be in an even poorer condition).

The proposed Airfield facility will likely comprise an approximately 1,700 m long runway with a taxiway, apron and a small terminal building located at its southern end, adjacent to the Camp (the future status of the second cross-runway is currently unknown). A longitudinal profile of the existing runway shows that it slopes from its northern and southern ends to a low point/drainage line located about 630 m south of its northern end. The elevation of the low point is about 176 mAHD some 2 to 3 m lower than ground elevations at its northern and southern ends.

The catchment area reporting to this low point and along the eastern edge of the runway, assuming that runoff will not be allowed to flow across the runway, is approximately 2.4 km^2 and will likely require a bank of culverts to be constructed beneath the runway. Alternatively a diversion berm and drain could be constructed around the facility, although this would likely require significant earthworks and may not be feasible given the existing topography. The preliminary design of the Airfield drainage works is presented in Section 4.0.

2.1.3 Existing Pre-Mining Catchment Delineation

Catchment areas affected by the Project were delineated for existing pre-mining conditions using the catchment boundaries from the Bureau of Meteorology[3] and watercourse shape files from Geoscience Australia[4]. The resulting catchment areas have been shown on Drawing No. –D01 and are summarised in Table 1.

Table 1: Existing Pre-Mining Catchment Areas

No.	Catchment Name	Area (km^2)
1	Turner River East Creek[see note 1]	28.463
2	Northern Creek (exc. Houston and Pilgangoora Creeks)[see note 2]	26.403
3	Houston Creek[see note 2]	17.553
4	Pilgangoora Creek[see note 2]	18.126
5	Southern Creek	18.844
6	Chinnamon Creek[see note 3]	287.544
	Total Combined Catchment Area	**396.933**

Notes:

1. Turner River East Creek catchment area measured to confluence with eastern headwaters.
2. Northern Creek catchment area measured to confluence with Chinnamon Creek and excluding Houston Creek (17.553 km^2) and Pilgangoora Creek (18.126 km^2). Both Houston and Pilgangoora Creeks report to Northern Creek, giving it a combined catchment area of 62.082 km^2.
3. All of the above creeks, excluding Turner River East Creek, report to Chinnamon Creek catchment which has a combined area of 368.470 km^2 upstream of its confluence with the Turner River.

2.1.4 Proposed End of Mining Catchment Delineation

A second catchment delineation was completed for conditions at the end of mining (assumed to be 18 years after start of mining) when the disturbance footprint is likely to be greatest. This delineation was based on the July 2018 preliminary design files for the 5 Mtpa Pit, WRD and TMF footprints and aerial photography/topographical survey data

[3] Bureau of Meteorology's Australian Hydrological Geospatial Fabric Dataset (V2.1, Feb 2013).
[4] Geoscience Australia's Geodata Topo 250K dataset (Series 3, 2006).

provided by PLS in January 2016. The resulting catchment areas have been shown on Drawing No. – D02 and are summarised in Table 2.

It should be noted that the various end of mining sub-catchment types were classified as follows:

i. *In-pit* – disturbed area bounded by ultimate pit crests;

ii. *Ex-pit Divertible In-pit* – ex-pit disturbed and undisturbed surface areas that will report in-pit, either directly or as a result of surface grading, dumping strategy, diversion drains, bunds etc. completed during operations;

iii. *Ex-pit Impacted* – ex-pit disturbed and undisturbed surface areas which will be "trapped" i.e. cut-off with no obvious outlet, or otherwise impacted due to the development of the mine facilities;

iv. *Ex-pit Off-site* – ex-pit disturbed surface areas that cannot practically be diverted in-pit; and,

v. *Off-site/Downstream* – areas that will not be affected by the Project and will generate runoff that will report off-site.

Table 2: Proposed End of Mining Catchment Areas

No.	Catchment Name & Sub-Catchment Type	Area[1] (km^2)	% of Catchment Area
1	**Turner River East Creek Catchment Area**		
i	In-pit	0.065	0.2%
ii	Ex-pit Divertible In-pit	-	-
iii	Ex-pit Trapped	-	-
iv	Ex-pit Off-site	0.053	0.2%
v	Off-site/Downstream	28.345	99.6%
	Sub-Total	**28.463**	**100%**
2	**Northern Creek Catchment Area**		
i	In-pit	0.178	0.7%
ii	Ex-pit Divertible In-pit	-	-
iii	Ex-pit Trapped	0.124	0.5%
iv	Ex-pit Off-site	0.737	2.8%
v	Off-site/Downstream	25.364	96.0%
	Sub-Total	**26.403**	**100%**

Table 2 (contd.): Proposed End of Mining Catchment Areas

No.	Catchment Name & Sub-Catchment Type	Area[1] (km^2)	% of Catchment Area
3	**Houston Creek Catchment Area**		
i	In-pit	0.738	4.2%
ii	Ex-pit Divertible In-pit	1.577	9.0%
iii	Ex-pit Trapped	0.444	2.5%
iv	Ex-pit Off-site	3.012	17.2%
v	Off-site/Downstream	11.624	66.2%
	Sub-Total	**17.553**	100%
4	**Pilgangoora Creek Catchment Area**		
i	In-pit	0.561	3.1%
ii	Ex-pit Divertible In-pit	0.037	0.2%
iii	Ex-pit Trapped[2]	1.165	6.4%
iv	Ex-pit Off-site	1.685	9.3%
v	Off-site/Downstream	14.678	81.0%
	Sub-Total	**18.126**	100%
5	**Southern Creek Catchment Area**		
i	In-pit	0.124	0.7%
ii	Ex-pit Divertible In-pit	0.123	0.7%
iii	Ex-pit Trapped	0.047	0.2%
iv	Ex-pit Off-site	0.674	3.6%
v	Off-site/Downstream	17.876	94.9%
	Sub-Total	**18.844**	100%
6	**Chinnamon Creek**		
i	In-pit	-	-
ii	Ex-pit Divertible In-pit	-	-
iii	Ex-pit Trapped	-	-
iv	Ex-pit Off-site	0.177	<0.1%
v	Off-site/Downstream	287.367	>99.9%
	Sub-Total	287.544	**100%**
	Total Combined Catchment Area	**396.933**	**100%**

Notes:

1. Areas progressively rehabilitated during life of Project have not been included in areas above.
2. Includes 0.566 km^2 existing "trapped" catchment upstream of abandoned Iron Stirrup pit void.
3. Topsoil storage areas have been excluded as it was assumed that with progressive rehabilitation throughout the life of the Project that the majority of stockpiled topsoil will have been used by the end of mining.

The end of mining sub-catchments were allocated to the pre-mining catchment area within which they were located and were summarised as follows:

- *Turner River East Creek Catchment Area* – will encompass the majority of the Lynas Find Pit and the northeast corner of the Monster No. 1 WRD.

At the end of mining the Lynas Find Pit crest area will be approximately 0.083 km^2, with some 0.065 km^2 (approximately 78%) of this area located within the Turner River East Creek catchment (Type i sub-catchment area).

No Type ii or Type iii sub-catchment areas have been identified at this stage.

It has been assumed that at the end of mining runoff from the northeastern face of the Monster No.1 WRD (0.053 km^2) cannot be directed into the open pit void and will report off-site and has therefore been classified as Type iv sub-catchment.

The remaining undisturbed Turner River East Creek catchment area (Type v sub-catchment) is in the order of 28.345 km^2 or approximately 99.6% of the pre-development catchment area.

- *Northern Creek Catchment Area* – will encompass the western edge of the Lynas Find Pit and the majority of the Monster Pit along with all of the Lynas Find and Monster No. 2 WRD's, the northwest corner of the Monster No.1 WRD and the northern edge of the Monster No. 3 WRD.

  At the end of mining the Lynas Find and Monster Pit crest areas will be approximately 0.083 and 0.198 km^2 respectively, with some 0.018 and 0.160 km^2 respectively of these areas located within the Northern Creek catchment. A combined Type i sub-catchment area of 0.178 km^2 has therefore been identified.

  It has been assumed that no runoff from the top surfaces and outer faces of WRD's can readily be diverted in-pit within this catchment. The ex-pit divertible (Type ii) sub-catchment area will therefore be zero.

  Trapped catchments will be formed by the development of Monster No. 2 and No. 3 WRD's on the downstream western and southern sides of the Monster Pit respectively. As a result, ex-pit impacted (Type iii) sub-catchment areas of approximately 0.063 and 0.061 km^2 have been identified at this stage.

  It has been assumed that runoff from the entire Lynas Find (0.274 km^2) and Monster No. 2 (0.312 km^2) WRD's and the northwest corner of the Monster No. 1 WRD (0.112 km^2) and northern edge of the Monster No. 3 WRD (0.039 km^2) cannot be directed into the open pit voids and will report off-site. This gives a total Type iv sub-catchment area of approximately 0.737 km^2.

  The remaining undisturbed Northern Creek catchment area (Type v sub-catchment) is in the order of 25.364 km^2 or approximately 96% of the pre-development catchment area.

- *Houston Creek Catchment Area* – in addition to the southern half of the Monster No. 1 WRD and majority of the Monster No. 3 WRD (as described above), this catchment area will encompass the entire Eastern Pit, Western WRD and ROM, along with the northern half of the Central Pit, the northern three-quarters of the Eastern WRD and the majority of the Stage 1 TMF Cells 1 and 2, all of which straddle the Houston Creek and Pilgangoora watershed divide.

  At the end of mining about 0.038 km^2 of the Monster Pit, 0.373 km^2 of the Eastern Pit and about 0.327 km^2 of the Central Pit crest will be located within the Houston Creek catchment, resulting in a combined Type i sub-catchment area of 0.738 km^2.

  It has been assumed that the majority of the top surface and western face of the Eastern WRD (0.870 km^2) will be shaped to direct runoff into the Eastern Pit. Runoff from the strip of remaining natural ground between the Eastern Pit and Eastern

WRD (0.707 km^2) will also be diverted into the Eastern Pit. The combined ex-pit divertible (Type ii) sub-catchment area will therefore be in the order of 1.577 km^2.

Trapped catchments will be formed by the development of the Western WRD on the downstream (west) side of the Eastern Pit (0.336 km^2). In addition trapped catchments will be formed along the upstream (west) side of the Eastern WRD at the northern (0.158 km^2) and southern (0.108 km^2) parts of the dump. As a result, an ex-pit impacted (Type iii) sub-catchment area of approximately 0.602 km^2 has been identified at this stage. It has been assumed that the ROM ramp can either be reconfigured or a minor diversion or culverts used to divert runoff from the area upstream of the ROM (between Central and Eastern Pits) downstream/off-site.

It has been assumed that runoff from the northern and eastern faces of the Eastern WRD (0.753 km^2) cannot be directed into the open pit void and will report off-site along with runoff from Monster No. 1 WRD (0.277 km^2), Monster No. 3 WRD (0.184 km^2) and all of Western WRD (0.566 km^2). In addition, runoff from the ROM (0.171 km^2) and Stage 1 TMF Cells 1 and 2 (1.061 km^2) will report off-site. This gives a Type iv sub-catchment area of some 3.012 km^2.

The remaining undisturbed catchment area (Type v sub-catchment) is in the order of 11.624 km^2 or approximately 66% of the pre-development catchment area.

- *Pilgangoora Creek Catchment Area* – will encompass all of the Southern Pit, Stage 2 TMF (Cell 3) and the Pilgangoora Creek Central Pit and TMF diversions. It will also comprise the southern half of the Central Pit, southern part of the Eastern WRD, northern half of the Southern WRD and the south-western flank of the Stage 1 TMF (Cells 1 and 2), all of which straddle the Pilgangoora Creek catchment divide.

  At the end of mining all of the Southern Pit crest area (0.117 km^2) and the southern part of the Central Pit (0.444 km^2) will be located within the Pilgangoora Creek catchment giving a Type i sub-catchment area of 0.561 km^2.

  It has been assumed that runoff from only a limited part of the East WRD top surface can be readily diverted in-pit. The ex-pit divertible (Type ii) sub-catchment area will therefore be 0.037 km^2.

  Two trapped catchments (0.428 km^2 east catchment and 0.171 km^2 west catchment) will be formed by the development of the southern part of the Eastern WRD to the east of the Central Pit. When combined with the trapped catchment area that reports to the abandoned Iron Stirrup pit void (0.566 km^2) , an ex-pit impacted (Type iii) sub-catchment area of 1.165 km^2 has been delineated within the Pilgangoora Creek catchment.

  Runoff from the Eastern WRD (0.288 km^2), Southern WRD (0.197 km^2) and upper surface of the Stage 2 TMF Cell 3 (0.933 km^2) and remainder of Cell 1/2 (0.118 km^2), along with runoff from both the Central Pit diversion (0.073 km^2) and TM diversion (0.076 km^2) will report off-site following relevant source controls, giving a Type iv sub-catchment area of approximately 1.685 km^2.

  The remaining undisturbed catchment area (Type v sub-catchment) is in the order of 14.678 km^2 or approximately 81% of the pre-development catchment area.

- *Southern Creek Catchment Area* – will encompass the entire South End Pit, the majority of the South End WRD and the southern part of the Southern WRD.

  At the end of mining the South End Pit crest area will be approximately 0.124 km^2 (Type i sub-catchment area).

It has been assumed that no runoff from the top surfaces and outer faces of WRD's can readily be diverted in-pit within this catchment. However, runoff from an area on the upstream (east) side of the South End Pit will report to the pit. The ex-pit divertible (Type ii) sub-catchment area will therefore be 0.123 km^2.

An ex-pit impacted (Type iii) sub-catchment area of approximately 0.047 km^2 will be "trapped" along the southeastern toe of the Southern WRD.

Runoff from the upper surface and northern slopes of the South End WRD (0.504 km^2) and the southern part of the Southern WRD (0.170 km^2) will report off-site following relevant source controls, giving a Type iv sub-catchment area of approximately 0.674 km^2.

The remaining undisturbed catchment area (Type v sub-catchment) is in the order of 17.876 km^2 or approximately 95% of the pre-development catchment area.

- *Chinnamon Creek Catchment Area* – only the southeastern toe of the South End WRD will be located within the Chinnamon Creek catchment. It has been assumed that runoff from this area will report off-site, giving a Type iv sub-catchment area of approximately 0.177 km^2.

  Given that there are no Type i, ii, or iii sub-catchments, the remaining undisturbed catchment area (Type v sub-catchment) is in the order of 287.367 km^2 or more than 99.9% of the pre-development catchment area.

Inspection of the total catchment areas in Table 1 and Table 2 shows that a total of about 5.3 km^2 or some 1.4% of the pre-mining total combined catchment area of 396.9 km^2 will be classified as either Type i, ii or iii sub-catchments. Runoff from these areas will not report off-site following the end of mining i.e. runoff will either be generated in-pit, be diverted in-pit or will become trapped due to the development of the mine facilities, and will be lost to downstream catchment areas.

The pre-mining catchment most greatly affected will be the Houston Creek catchment with approximately 17% of the pre-mining area classified as either Type i, ii or iii sub-catchments. The Chinnamon Creek catchment will be the least affected with no areas similarly classified.

2.1.5 Proposed Mining Area Catchment Runoff Volume Estimates

In order to develop runoff volume estimates from the existing pre-mining and proposed end of mining delineated catchments the Rational Method runoff coefficients shown in Table 3 were applied to 24 hour and 72 hour rainfall depths developed previously for the Pilgangoora site (refer to rainfall intensity-frequency-duration relationship in Appendix B).

Table 3: Runoff Coefficients for Mine Site Catchments

Catchment Type	Runoff Coefficient, C
Undisturbed catchments	25%
In-pit slopes and benches	100%
Rock Dump Top (no capping, no rehab)	15%
Rock Dump Sides (no capping, no rehab)	40%
Recently graded areas (gravelly soil, no rehab)	55%
Haul Roads, sheeted	70%

The resulting runoff volume estimates for the existing pre-mining and proposed end of mining catchments for 24 and 72 hour durations events with a range of ARI's and PMP are shown in Tables 4 and 5 (a calculation worksheet is presented in Appendix B).

Table 4: Existing Pre-Mining Catchment Runoff Volume Estimates (24 & 72 hour Duration Events)

No.	Catchment Name	Runoff Volume (,000 m^3) for 24 hour Duration Events					
		5 yr ARI	10 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI	PMP/PMF
1	Turner River East Creek	958	1,249	1,564	2,032	2,412	8,895
2	Northern Creek[1]	889	1,158	1,451	1,885	2,237	8,251
3	Houston Creek	591	770	965	1,253	1,487	5,485
4	Pilgangoora Creek	610	795	996	1,294	1,536	5,664
5	Southern Creek	635	827	1,035	1,345	1,597	5,889
6	Chinnamon Creek	9,683	12,616	15,801	20,523	24,362	89,858
	Total	**13,367**	**17,415**	**21,811**	**28,331**	**33,630**	**124,042**

No.	Catchment Name	Runoff Volume (,000 m^3) for 72 hour Duration Events					
		5 yr ARI	10 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI	PMP/PMF
1	Turner River East Creek	1,203	1,546	1,906	2,419	2,958	16,010
2	Northern Creek[1]	1,116	1,434	1,768	2,244	2,744	14,852
3	Houston Creek	742	954	1,175	1,492	1,824	9,874
4	Pilgangoora Creek	766	985	1,214	1,540	1,884	10,196
5	Southern Creek	797	1,024	1,262	1,601	1,958	10,600
6	Chinnamon Creek	12,156	15,621	19,251	24,434	29,883	161,744
	Total	**16,780**	**21,563**	**26,575**	**33,729**	**41,251**	**223,275**

Note 1: Excludes Houston and Pilgangoora Creeks which sit within overall Northern creek catchment.

Review of the volumetric estimates shown in Table 4 indicate that the six existing pre-mining catchment areas jointly produce between 13,367,000 m^3 and 33,630,000 m^3 of runoff as a result of 5 to 100 year ARI 24 hour duration events respectively. Runoff volumes of between 16,780,000 m^3 and 41,251,000 m^3 are estimated as a result of 5 to 100 year ARI 72 hour duration events respectively. The PMP event could yield runoff volumes in the order of 120 million and 220 million m^3 for 24 and 72 hour duration events respectively. Given that this is for pre-mining conditions, all of this runoff reports off-site/downstream.

Table 5 for end of mining conditions shows that the combined Type iv and v runoff volume that report off-site/downstream, is about 99.6% of the pre-mining volume for the same events i.e. approximately 0.4% of the pre mining catchment runoff volume will either be generated in-pit, diverted in-pit or become trapped due to the development of the mine facilities and will be lost to downstream catchment areas.

The pre-mining catchment most greatly affected will be the Houston Creek catchment with the volume of runoff that reports off-site post-mining about 94% of the pre-mining runoff volume. The Pilgangoora Creek off-site post-mining runoff volume will be about 96% of that under pre-mining conditions, while there will only be negligible (<1%) changes in the off-site post-mining runoff volumes from the Turner River East, Northern, Southern and Chinnamon Creek catchments.

Nevertheless opportunities exist to significantly reduce the extent of ex-pit impacted (Type iii) sub-catchment areas by making modifications to WRD locations and designs.

Table 5: Proposed End of Mining Catchment Runoff Volume Estimates

No.	Catchment Name	Sub-Catchment	Runoff Volume (,000 m^3) for 24 hour Duration Events						Runoff Volume (,000 m^3) for 72 hour Duration Events					
			5 yr ARI 24 hour	10 yr ARI 24 hour	20 yr ARI 24 hour	50 yr ARI 24 hour	100 yr ARI 24 hour	PMP/ PMF	5 yr ARI 72 hour	10 yr ARI 72 hour	20 yr ARI 72 hour	50 yr ARI 72 hour	100 yr ARI 72 hour	PMP/ PMF
1	Turner River East Creek Catchment Area	i In-pit	9	11	14	19	22	81	11	14	17	22	27	146
		ii Ex-pit Divertible In-pit	0	0	0	0	0	0	0	0	0	0	0	0
		iii Ex-pit Trapped	0	0	0	0	0	0	0	0	0	0	0	0
		iv Ex-pit Off-site	3	4	5	6	7	27	4	5	6	7	9	48
		v. Off-site/Downstream	955	1,244	1,558	2,023	2,402	8,858	1,198	1,540	1,898	2,409	2,946	15,944
		Sub-Total Off-site	**966**	**1,259**	**1,577**	**2,048**	**2,431**	**8,966**	**1,213**	**1,559**	**1,921**	**2,438**	**2,982**	**16,138**
2	Northern Creek Catchment Area	i In-pit	24	31	39	51	60	223	30	39	48	61	74	401
		ii Ex-pit Divertible In-pit	0	0	0	0	0	0	0	0	0	0	0	0
		iii Ex-pit Trapped	5	7	8	11	13	47	6	8	10	13	15	84
		iv Ex-pit Off-site	40	52	65	84	100	369	50	64	79	100	123	663
		v. Off-site/Downstream	854	1,113	1,394	1,810	2,149	7,926	1,072	1,378	1,698	2,155	2,636	14,267
		Sub-Total Off-site	**923**	**1,202**	**1,506**	**1,956**	**2,322**	**8,564**	**1,159**	**1,489**	**1,835**	**2,329**	**2,848**	**15,415**
3	Houston Creek Catchment Area	i In-pit	99	130	162	211	250	923	125	160	198	251	307	1,661
		ii Ex-pit Divertible In-pit	85	111	139	180	214	789	107	137	169	214	262	1,419
		iii Ex-pit Trapped	18	23	29	38	45	167	23	29	36	45	55	300
		iv Ex-pit Off-site	162	211	265	344	408	1,506	204	262	323	410	501	2,711
		v. Off-site/Downstream	391	510	639	830	985	3,633	491	631	778	988	1,208	6,539
		Sub-Total Off-site	**762**	**993**	**1,244**	**1,616**	**1,918**	**7,075**	**957**	**1,230**	**1,516**	**1,924**	**2,353**	**12,735**
4	Pilgangoora Creek Catchment Area	i In-pit	76	98	123	160	190	701	95	122	150	191	233	1,262
		ii Ex-pit Divertible In-pit	2	3	3	4	5	19	3	3	4	5	6	33
		iii Ex-pit Trapped	47	61	77	100	118	437	59	76	94	119	145	786
		iv Ex-pit Off-site	91	118	148	192	228	843	114	146	180	229	280	1,517
		v. Off-site/Downstream	494	644	807	1,048	1,244	4,587	621	797	983	1,247	1,525	8,256
		Sub-Total Off-site	**710**	**925**	**1,158**	**1,504**	**1,786**	**6,586**	**891**	**1,145**	**1,411**	**1,791**	**2,190**	**11,855**

Table 5 (contd.): Proposed End of Mining Catchment Runoff Volume Estimates

No.	Catchment Name	Sub-Catchment	Runoff Volume (,000 m^3) for 24 hour Duration Events						Runoff Volume (,000 m^3) for 72 hour Duration Events					
			5 yr ARI 24 hour	10 yr ARI 24 hour	20 yr ARI 24 hour	50 yr ARI 24 hour	100 yr ARI 24 hour	PMP/ PMF	5 yr ARI 72 hour	10 yr ARI 72 hour	20 yr ARI 72 hour	50 yr ARI 72 hour	100 yr ARI 72 hour	PMP/ PMF
5	Southern Creek Catchment Area	i In-pit	17	22	27	35	42	155	21	27	33	42	52	279
		ii Ex-pit Divertible In-pit	7	9	11	14	17	62	8	11	13	17	20	111
		iii Ex-pit Trapped	2	2	3	4	5	18	2	3	4	5	6	32
		iv Ex-pit Off-site	36	47	59	77	91	337	46	59	72	92	112	607
		v. Off-site/Downstream	602	784	982	1,276	1,515	5,586	756	971	1,197	1,519	1,858	10,055
		Sub-Total Off-site	664	864	1,083	1,406	1,669	6,157	833	1,070	1,319	1,674	2,048	11,083
6	Chinnamon Creek Catchment Area	i In-pit	0	0	0	0	0	0	0	0	0	0	0	0
		ii Ex-pit Divertible In-pit	0	0	0	0	0	0	0	0	0	0	0	0
		iii Ex-pit Trapped	0	0	0	0	0	0	0	0	0	0	0	0
		iv Ex-pit Off-site [no]	10	12	16	20	24	89	12	15	19	24	29	159
		v. Off-site/Downstream	9,677	12,608	15,791	20,511	24,347	89,802	12,148	15,611	19,239	24,419	29,865	161,644
		Sub-Total Off-site	9,687	12,621	15,806	20,531	24,371	89,891	12,160	15,627	19,258	24,443	29,894	161,803
Total (ALL Catchment Types)			**13,711**	**17,864**	**22,374**	**29,061**	**34,497**	**127,239**	**17,213**	**22,119**	**27,260**	**34,599**	**42,314**	**229,030**
Total Off-Site (Type iv + Type v)			**13,315**	**17,348**	**21,727**	**28,221**	**33,500**	**123,561**	**16,715**	**21,480**	**26,472**	**33,599**	**41,091**	**222,410**
Pre-Mining Volume (,000 m3)			**13,367**	**17,415**	**21,811**	**28,331**	**33,630**	**124,042**	**16,780**	**21,563**	**26,575**	**33,729**	**41,251**	**223,275**
% of Pre-Mining Volume			99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%	99.6%

3.0 SURFACE WATER MANAGEMENT

3.1 Hydrological Risk

All the watercourses and drainages in the vicinity of the Project site are ephemeral, flows may occur periodically during the summer months from January to March, when the potential exposure to high intensity rainfall is greatest. Occasionally such flows may be high and may cause flooding if appropriate measures are not in place.

The hazard that such flooding poses to the Project infrastructure depends, amongst other things, on the following:

- the magnitude of the flood event;
- the proximity of the facility to the watercourse in flood;
- the sensitivity of the facility to flooding; and,
- the level of protective flood measures provided to the facility.

While the latter three factors can be controlled or engineered to some degree, the magnitude of the naturally occurring rainfall-runoff events may lead to flooding that cannot be controlled.

Although significant rainfall-runoff events do not occur cyclically, especially in a climatic region as variable as this, their probability of occurrence within any given period can be estimated. The reciprocal of this probability is typically expressed as an ARI and is the time that, on average, elapses between two events that equal or exceed the magnitude in question.

Table 6 shows the percentage probability for a range of different ARI flood events and PMP that could occur during an assumed 18 year long operational period. It should be noted that for current purposes a conservative ARI of 1 million years has been adopted for the PMP (within the field of hydrology it is commonly accepted that PMP is much less frequent than 1 million year ARI).

Table 6: Percentage Probability of N-Year ARI Flood Event Occurring During 18 Year Operational Period

Average Recurrence Interval (ARI)	5 year	10 year	20 year	50 year	100 year	200 year	500 year	PMP (1 million yr)
Probability of Occurrence in 18 yrs.	98%	85%	60%	31%	17%	9%	4%	0.0018%

Typically a range of ARI events are used for the design of various mine facilities, depending on the consequences of failure and the period of exposure. Clearly as the duration of the exposure period increases due to a longer operational life the probability of a rainfall event of a certain severity occurring is greater. Therefore it is recommended that a 100 year ARI event be adopted for the design of all surface water management measures during operations and that all landforms that remain in closure be capable of withstanding a PMP/PMF event.

3.2 Pit & TMF Diversion Channel Design Approach

Inspection of the available topographical data and aerial photography indicate that the greatest potential flood risk to the proposed Project relates to the intersection of Pilgangoora Creek by both the southern crest of Central Pit and the Stage 2 TMF embankment. These intersections of the existing Pilgangoora Creek channel will occur at various stages of the operational life of the Project and will remain after the end of mining. Flood risks to the proposed Central Pit and TMF and impacts on the Pilgangoora flow regime should therefore be minimised and flood protection provided by the construction of flood diversion channels designed to safely convey 100 year ARI peak flows with dry freeboard during operations and capable of withstanding the PMF event during closure. The preliminary engineering design of these diversions is described in more detail in Section 4.0.

In addition, flood protection should be provided to all the proposed pits by a combination of the following measures:

- WRD's strategically placed along the eastern (upstream) side of all pits where possible;
- Sections of rock-armoured flood protection berm/diversion drain placed around pit crests where practicable (berms should be offset sufficiently far from pit crests to also serve as part of the closure berm if required);
- Pit crest/safety berm placed as close as geotechnically possible to pit crest to minimise runoff from areas adjacent to pit crests;
- "Roll-over" at the top of pit ramps; and,
- Ex-pit roadside drains to direct runoff away from the pits.

It should be noted that as mining proceeds through the existing range of hills that several relatively small upslope catchment areas will be intersected by the development of the pit crests. In many cases it will be impractical to construct flood protection berms and drains and runoff reporting from such areas will likely have to be managed in-pit. This is discussed further in the following section.

3.3 West Waste Rock Dump

The West WRD from years 3/4 onwards prevents runoff from the East WRD and an approximately 25 ha catchment to north of the Eastern Pit from reporting off-site towards the west. This forms a trapped catchment. If this area is not allowed an outlet, runoff could report to the Eastern Pit.

It is proposed to provide a drain for this area under the West WRD, discharging to existing drainage line to the west. The drain would be constructed by excavating a channel along the drainage alignment, backfilling with coarse competent rock material and covering with geotextile prior to construction of the waste landform.

More detailed design of this structure should be undertaken as part of the detailed design process.

3.4 In-Pit Runoff Volume Estimate

Even with the provision of the surface water management measures identified above some amount of runoff will still report to the floor of the various pits from direct precipitation and from small, adjacent trapped catchments. Such rainfall-runoff will typically collect at the lowest points on the pit floors and will need to be removed using in-pit sump pumps in order to minimise interruptions to operations (given that no underground workings are proposed, it is not considered to pose a significant mine safety risk).

An estimate of the anticipated rainfall-runoff volume from a range of events is presented in Table 7 for the six proposed open pits.

The volumes presented in Table 7 are based upon pit crest areas plus a 15% allowance for small trapped areas adjacent to the pit crests, a 100% runoff coefficient and the rainfall depths of 104, 169, 217, 268, 340, 416 and 2,250 mm for 2, 5, 10, 20, 50 and 100 year ARI and PMP 72 hour duration events (refer to rainfall IFD and PMP estimate in Appendix A).

Table 7: In-Pit Runoff Volume Estimates

Rainfall Event	In-Pit Runoff[1] (m^3)					
	Lynas Find[2]	Monster[3]	Eastern[4]	Central[5]	Southern[6]	South End[7]
2 year-72 hr	10,000	24,000	45,000	92,000	14,000	15,000
5 year-72 hr	16,000	39,000	73,000	150,000	23,000	24,000
10 year-72 hr	21,000	50,000	93,000	193,000	29,000	31,000
20 year-72 hr	25,000	61,000	115,000	238,000	36,000	38,000
50 year-72 hr	32,000	78,000	146,000	302,000	46,000	49,000
100 year-72	39,000	95,000	179,000	369,000	56,000	60,000
PMP-72 hr	214,000	513,000	966,000	1,998,000	304,000	322,000

Notes:
1. +15% allowance for runoff from areas adjoining pit crest.
2. Lynas Find ultimate pit crest area = 82,525 m^2.
3. Monster ultimate pit crest area = 198,400 m^2.
4. Eastern ultimate pit crest area = 373,360 m^2.
5. Central ultimate pit crest area = 772,136 m^2.
6. Southern ultimate pit crest area = 117,450 m^2.
7. South End ultimate pit crest area = 124,440 m^2.

As mentioned above, the periodic collection of in-pit runoff within the open pits is likely to only lead to operational delays and it is therefore unlikely that special measures such as a minimum capacity sumps and dedicated, fixed pumps are warranted. When it is necessary to remove runoff that might periodically collect on the floor of these pits, it is envisaged that mobile pumps will be used temporarily, with pumpage delivered either ex-pit or possibly to an adjoining, non-active pit.

3.5 Site Wide Surface Water Management

In addition to protecting the proposed pits against flooding from low frequency flood events such as the 100 year ARI event during operations as discussed above, it will also be necessary to manage runoff from more frequent, less significant rainfall events. Although such events give rise to much lower runoff rates and volumes they should be managed appropriately in order to protect Project infrastructure, minimise erosion and reduce the potential loss of sediment laden or other contaminated runoff from the Project.

For the management of stormwater the various Project facilities should therefore be generally classified as follows:

- Plant Area;
- Mine Services/Workshops Area;
- Hazardous Material Storage Areas;
- Disturbed Mine Areas; and,
- Undisturbed Mine Areas.

3.5.1 Plant Area

Rain falling within wet processing areas should be collected within bunded areas and returned to the process. Provision should be made for the return of such flows to the process by means of drains, launders, sumps, pumps etc. Alternatively such water could be used for dust suppression within the process area if of acceptable quality.

3.5.2 Mine Services/Workshops Area

The Mine Services/Workshop Area should include surface water runoff and wash down water drainage and recovery systems. Rainfall runoff from the Mine Yard/Workshops area including roads, building roofs, laydown yards etc. should be captured in open drains. The drains should report to Water Management/Sedimentation Pond(s) where water should be temporarily stored prior to reuse.

To aid management of runoff from areas likely to be impacted by hydrocarbons, e.g. fuel storage and dispensing areas, truck wash and workshops, it is proposed to capture runoff from these areas using open drains that report to an oily water separator (OWS) provided upstream of Water Management/Sedimentation Pond(s).

Mine Services/Workshops area drains should be sized for the peak of the 100 year ARI event as a minimum. Flow velocities along such drains should be limited to minimise erosion and the generation of sediment.

3.5.3 Hazardous Materials Storage Areas

All chemical, oil and other hazardous material storage areas within the Plant or Mine Services/Workshop Area should be enclosed within a berm in accordance with the relevant codes and standards. Water collected within the berms should be assessed and, if suitable, should be discharged to Water Management/Sedimentation Pond(s). Water collected within the berms that is found to be impacted should be disposed of appropriately.

3.5.4 Disturbed Areas

Outside the Plant and Mine Services/Workshops areas the mine facilities will comprise various pits, WRD's, topsoil stockpiles, ROM, TMF and access and haul roads. Source controls should be used to improve the quality of runoff from these facilities.

Runoff from these facilities should be directed to Water Management/Sedimentation Pond(s) where possible.

For runoff within the proposed pit, source controls should comprise practices such as mining from upper benches or processing stockpiled material following significant rainfall events. In-pit sumps should be used to settle out sediment from collected runoff prior to pumping to surface for re-use or discharge off-site.

3.5.5 Undisturbed Areas

All practical steps should be taken to divert runoff from undisturbed catchment areas around all proposed mine facilities to minimise potential lowering of water quality.

3.6 Surface Water Management at Closure

3.6.1 General

The catchment areas likely to be affected at the end of mining were presented in Section 2.0 and an estimate was made of runoff volume impacts for 24 and 72 hour events for a range of different ARI's (2 to 100 year ARI and PMP/PMF).

As stated earlier, all landforms that remain post closure i.e. pit voids, WRD's and Pilgangoora Creek diversion channels, should be designed, constructed and rehabilitated to safely withstand the PMP/PMF event. Clearly, given the magnitude of the PMP/PMF event, if it were to occur, it would not only impact the proposed Pilgangoora mining area but would also likely have a considerable effect on both natural (undisturbed) and modified (disturbed) catchments and infrastructure across the region.

The immediate effects of the tropical depression related event(s) leading to the PMP/PMF would include exceptionally high/damaging winds, intense rainfall, concentrated runoff, flooding, erosion and sediment transport/deposition, storm surge, airborne debris, removal of foliage/tree canopy etc. The PMP/PMF would then likely be followed by a prolonged period of extraordinarily high flows and water levels along both local creeks (Turner River East, Northern, Houston, Pilgangoora and Southern Creeks) and regional rivers (Turner, Yule and Strelley Rivers). These flows would inundate floodplains causing road/rail/power/water infrastructure damage or loss, flooding of pastoral land, disruption of road/rail/air/sea transportation etc. Mining across the Pilbara region would be negatively impacted with many mines closed for extended periods and some perhaps failing to re-open.

The PMP/PMF effects at the proposed Pilgangoora mining area post-closure would be moderated to some extent by the fact that, as reported previously, the regional watershed divide is located about 2 km to the east of the site and the upstream catchment areas are relatively small (<10 km^2 in all cases). In addition the sympathetic design of the proposed landforms e.g. provision of strategic "gaps" between landforms and appropriately design Pilgangoora Creek diversion channels, will largely ensure that peak flows along all main creeklines reports downstream unimpeded.

Potential surface water impacts on Project landforms at the end of mining are discussed in the following sections (it should be noted that more detailed completion criteria and measurement tools have been developed by others and have been presented elsewhere in the Project documentation).

3.6.2 Pit Voids

The ultimate pits will be established within a range of north-south trending hills of up to about 80 m relief, with pit crests mostly daylighting at elevated locations and primary flood protection will be provided by the construction of WRD's along the eastern/upstream side of the pits. For these reasons large inflows of runoff to the pit voids are not expected post-closure.

Even if this were to occur there is sufficient capacity within all five ultimate pit voids to safely store the PMP/PMF event with freeboard, even assuming predicted maximum pit lake levels and antecedent "high rainfall" conditions.

The potential for loss of potentially poorer quality water stored in-pit off-site as a result of a PMP/PMF event is therefore considered to be highly unlikely.

3.6.3 Waste Rock Dumps and TMF

Prior to the cessation of mining the upper surfaces and side slopes of the various WRD's and the TMF will be fully rehabilitated and re-grading and drainage measures will be used to maximise the diversion of storm runoff in-pit.

Where WRD and TMF toe-lines daylight near the valley floors and close to the main creeklines within the existing local range of hills it may be necessary to provide broken rock (riprap) protection along the face up to a pre-determined elevation. Detailed hydraulic/flood modelling has not been carried out at this preliminary stage, but such protection measures are not considered necessary for WRD's in Northern, Houston and Southern Creek catchments due to the provision of "gaps" between landforms.

However, preliminary analyses indicates that limited sections of the East WRD and TMF embankment will require rock armouring as a result of conveying maximum flow depths along the proposed diversion channels under PMP/PMF conditions (refer to Section 4.0). Detailed hydraulic modelling should be completed as part of the detailed design of the Project.

3.6.4 Pilgangoora Creek Diversions

The southern crest of the proposed Central Pit and Stage 2 TMF embankment will both intersect Pilgangoora Creek and will require diversion channels to be constructed. As discussed in more detail in Section 4.0, both diversions have been conceptualised as rock-cut channels capable of conveying the PMP/PMF event. Under PMP/PMF conditions the flow velocity will likely increase by some 50 to 60% over that for the 100 year ARI event but, given that the bulk of both channels will be rock-cut (i.e. the channel inverts and sides will comprise fresh, hard country rock requiring drilling and blasting to construct) and that peak flow conditions will likely only last for a few hours, it is unlikely that significant erosional damage will occur to either of the channels.

Detailed hydraulic modelling should be completed as part of the detailed design of the Project.

3.6.5 Haul Roads

Haul road drainage should be directed in-pit wherever possible. For roads downstream of the pits, following the cessation of mining, roads should be breached at various locations and drainage lines reinstated to a natural, pre-development state.

4.0 PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES

A series of staged development plans has been developed for the 5 Mtpa Project at nominal five year intervals starting in the pre-development condition (Year 0) and ending in Year 18, as shown in Drawing Nos. -D03 to D07. These drawings comprise the December 2017 pit, WRD and TMF design information only. It has been assumed that there are no changes to the 2 Mtpa DFS layout of the Plant, Camp and other key Project facilities.

Insufficient information was available to the DFS to identify surface water management measures that will be required for start-up (Year 5 infrastructure shapes were earliest available). However, major surface water management works that will be required in the future include the following:

1. Central Pit/Pilgangoora Creek Stage 1 Diversion (required between Yr 0 and Yr 5);

2. Central Pit/Pilgangoora Creek Stage 1 Diversion (required between Yr 10 and Yr 15); ; and,

3. TMF Stage 2/Pilgangoora Creek diversion (required between Yr 5 and Yr 9).

It should be noted that the physical dimensions and timing of the Central Pit/Pilgangoora Creek Diversion have changed for the 5 Mtpa Project, while it is only the timing of the TMF Stage 2/Pilgangoora Creek diversion that has changed for the 5 Mtpa Project.

The preliminary engineering design of the above measures are presented in the following sections and presented on the accompanying preliminary engineering Drawing Nos. J1723-D8 to –D10.

4.1 Central Pit/Pilgangoora Creek Diversion

4.1.1 General

As identified earlier, the southern crest of the Central Pit will intersect Pilgangoora Creek and it will therefore be necessary to construct a diversion channel to manage periodic flows along the creek. This diversion will be constructed in two stages, namely: ***Diversion Stage 1*** – will be required between start-up and Year 5 in order to protect the southern limit of the Central Stage 1 to 4 Pit, and ***Diversion Stage 2*** – will be required between Year 10 and Year 15 to protect the Central Stage 5 Pit to the southwest. As noted earlier it should be understood that both the physical dimensions and timing of the Central Pit/Pilgangoora Creek Diversion have changed for the 5 Mtpa Project.

Given the potential risk to mining operations in the Central Pit and the adjacent Southern Pit, it is recommended that the proposed diversion should be capable of safely passing the 100 year ARI event with freeboard during operations and withstanding the PMP/PMF event in closure. It should also be noted that there is sufficient capacity available within the ultimate Central and Southern Pit voids to store excess runoff from the PMP/PMF event in addition to the maximum anticipated pit lake levels. The ability to utilise this “off-line” storage for excess floodwater has not been explored in this preliminary report, but should be considered as part of the future/detailed design of the Pilgangoora Creek diversion.

4.1.2 Hydrological Analysis

The upstream catchment area to the east of the Central Pit is approximately 6.350 km^2. This area is conservatively based on the pre-mining catchment area in the event that the proposed footprint of the adjacent pits and dumps is modified in the future. The Regional Flood Frequency Estimation Model[5] was applied to the upstream catchment area to generate peak flow estimates for events of between 2 and 100 year ARI and the Rational Method was conservatively applied to estimate the PMF peak flow. The resulting peak flow estimates are summarised in Table 8 (refer to Appendix B for model output and calculations).

Table 8: Pilgangoora Creek Upstream of Central Pit - Peak Flow Estimates

Average Recurrence Interval (ARI)	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	PMP[1]
Peak Flow Estimate (m^3/s)	13	38	62	91	132	164	880

Note1: PMP peak flow conservatively assumes 100% runoff from 60 minute critical duration event (500 mm/hr)

4.1.3 Hydraulic Design

The diversion has been conceptualised as a 25 m base width channel with 2H:1V sideslopes and 6 m maximum height flood bunds along both sides of its entire length (detailed hydraulic modelling will be completed to confirm this preliminary design as part of the detailed design of the Project). The parameters shown in Table 9 were therefore adopted for preliminary hydraulic design purposes (refer to diversion plan and typical sections on Dwg. Nos. –D08 – Stage 1 Diversion and –D09 – Stage 2 Diversion).

[5] Recently developed as part of the 4th edition of Australian Rainfall and Runoff, 2016.

Table 9: Central Pit/Pilgangoora Creek Stage 1 & 2 Diversion Design Parameters

Parameter	Unit	Stage 1	Stage 2	Comment
Channel Length	m	552.8	508	-
Inlet Invert Elevation	mRL	184.61	185.97	Based on survey pick-up
Outlet Invert Elevation	mRL	180.67	183.73	Based on survey pick-up
Minimum Channel Slope	%	0.71	0.44	
Manning's Roughness 'n'	-	0.045	0.045	Assumed jagged rock surface
Channel Base Width	m	25	25	-
Channel/Bund Sideslope Angle	-	26.6°	26.6°	2H:1V
Channel Depth/Bund Height (min.)	m	6.0	6.0	Top of berm to channel invert
Channel Top Width (min.)	m	49.0	49.0	Width between shoulders
Flood Bund Crest Width (min.)	m	5.0	5.0	-
PMP/PMF Channel Flow Depth	m	5.4	6.0	PMP/PMF peak flow depth
PMP/PMF Freeboard	m	0.6	0	-
100 year ARI Channel Flow Depth	m	2.1	2.4	100 yr ARI peak flow depth
100 year Freeboard	m	3.9	3.6	-

The Stage 1 diversion will comprise an approximately 553 m long channel with a 25 m base width and 2H:1V (26.6°) sideslopes. The channel will be aligned between the ultimate Central and Southern Pit crests and will slope at a gradient of about 0.71% to match existing upstream and downstream creek elevations. Flood bunds with a 5 m wide crest will be constructed along both sides of the diversion to a minimum height of 6 m above the channel invert. Approximately 45,000 m^3 of cut and some 74,000 m^3 of fill will be required to construct the Stage 1 diversion. Assuming that all material excavated from the channel can be re-used to construct the flood bunds, a further 29,000 m^3 will need to be imported from other on-site sources to meet the shortfall.

The Stage 2 diversion will comprise an approximately 508 m long channel with a 25 m base width and 2H:1V (26.6°) sideslopes. The channel will be aligned around the Central Stage 5 Pit crest and will slope at a gradient of about 0.44% to match the existing upstream creek elevation and tie-in with the Stage 1 diversion channel. Flood bunds with a 5 m wide crest will be constructed along both sides of the diversion to a minimum height of 6 m above the channel invert. Approximately 64,000 m^3 of cut and some 34,000 m^3 of fill will be required to construct the Stage 2 diversion. Assuming that the fill requirement can be met from the excavated material, there will be in the order of 30,000 m^3 of surplus excavated material from the channel cutting to be dumped within the proposed WRD's and/or TMF embankment.

Detailed hydraulic modelling should be completed to confirm these findings as part of the detailed design of the Project.

4.2 TMF Stage 2/Pilgangoora Creek Diversion

4.2.1 General

For the 5 Mtpa Project it will be necessary to start depositing tailings into a third cell at the TMF approximately nine years after the start of mining (for the previous 2 Mtpa Project this was not necessary until after approximately 20 years). The TMF Stage 2 embankment and impoundment will therefore be required in advance of Year 9 and will be built over approximately 1,600 m of the existing Pilgangoora Creek. Consequently it will be necessary to construct a diversion channel to manage periodic flows along the creek.

Given that the diversion will protect the TMF it is recommended that the proposed diversion should be capable of safely passing the 100 year ARI event with freeboard during operations and withstanding the PMP/PMF event in closure.

As noted earlier it should be understood that only the timing of the TMF Stage 2/Pilgangoora Creek Diversion have changed for the 5 Mtpa Project and the physical dimensions of the preliminary design are exactly the same as those for the 2 Mtpa Project.

4.2.2 Hydrological Analysis

The upstream catchment area to the east of the Central Pit is approximately 8.766 km^2. This area is conservatively based on the pre-mining catchment area in the event that the proposed footprint of the proposed facilities is modified in the future.

The Regional Flood Frequency Estimation Model[6] was applied to the upstream catchment area to generate peak flow estimates for events of between 2 and 100 year ARI and the Rational Method was conservatively applied to estimate the PMF peak flow. The resulting peak flow estimates are summarised in Table 10 (refer to Appendix B for model output and calculations).

Table 10: Pilgangoora Creek Upstream of Stage 2 TMF - Peak Flow Estimates

Average Recurrence Interval (ARI)	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	PMP[1]
Peak Flow Estimate (m^3/s)	16	46	74	108.0	157	196	1,220

Note1: PMP peak flow conservatively assumes 100% runoff from 60 minute critical duration event (500 mm/hr)

4.2.3 Hydraulic Design

The diversion has been conceptualised as a 15 m base width channel with 0.58H:1V (60°) cut batters, 5 m inter-bench height and a 5 m wide cut/fill berm along both sides of its 2,190 m length . The 15 m channel base width was based on a minimum practical working width i.e. to allow a large excavator to swing, rather than for hydraulic reasons. The parameters shown in Table 11 were therefore adopted for preliminary hydraulic design purposes (refer to diversion plan and cross-section on Dwg. No. –D10).

[6] Recently developed as part of the 4th edition of Australian Rainfall and Runoff, 2016.

Table 11: TMF Stage 2/Pilgangoora Creek Diversion Channel Design Parameters

Parameter	Unit	Value	Comment
Channel Length	m	2,190	-
Inlet Invert Elevation	mRL	175.0	Based on survey pick-up
Outlet Invert Elevation	mRL	169.0	Based on survey pick-up
Minimum Channel Slope	%	0.27	
Manning's Roughness 'n'	-	0.045	Assumed jagged rock surface
Channel Base Width	m	15	-
Channel Sideslope Angle	-	60°	0.58H:1V
Channel Depth (min.)	m	13.5	Top of berm to channel invert
Channel Top Width (min.)	m	30.7	Width between shoulders
PMP/PMF Channel Flow Depth	m	13.3	PMP/PMF peak flow depth
PMP/PMF Freeboard	m	0.2	-
100 year ARI Channel Flow Depth	m	4.5	100 yr ARI peak flow depth
100 year Freeboard	m	9.0	-

The proposed diversion alignment comprises an approximately 940 m and 750 m long straight sections aligned east-west and north-south respectively, which are joined with a 235 m radius horizontal curve (90° deflection angle). A second 235 m radius horizontal curve is used to direct flow at the channel outlet (these horizontal curve radii are far in excess of that required to minimise separation effects around the outside of the curve which could lead to increased scouring). This alignment has been chosen to accommodate the current Project tenement boundaries and the proposed TMF Stage 2 embankment toe-line. If either the tenement boundaries or TMF embankment design are changed, it may be possible to modify the diversion alignment.

The channel and cut/fill berm should be graded at 0.27% longitudinally to match existing river bed elevations at the inlet and outlet of the proposed diversion channel. The channel cutting will be approximately 10.5 m deep at the deepest point, some 475 m downstream of the inlet.

The proposed channel cutting has been assumed to have 60° (0.58H:1V) side slopes, 5 m inter-bench height and 5 m wide benches. Compacted earthfill berms will be constructed along both sides of the diversion up to a maximum height of 13.5 m above the channel invert. These geotechnical parameters should be confirmed by PLS's geotechnical consultant.

The channel inlet and outlet will be formed by placement of select rock from the channel excavation and will be lined with riprap to provide additional security. The inlet and outlet design should be considered in more detail at the detailed design stage.

Preliminary earthworks modelling indicates that approximately 354,000 m^3 of cut and some 612,000 m^3 of fill will be required to construct the diversion. Assuming that the bulk of the cut material from the channel can be re-used for the construction of the diversion berms, there will be a shortfall of some 258,000 m^3 of fill material that will need to imported from elsewhere on-site.

Detailed hydraulic modelling should be completed to confirm these findings as part of the detailed design of the Project.

4.3 Preliminary Quantity Estimation

Preliminary construction quantities for the proposed water management measures identified above are summarised in Table 12. These quantities have been measured directly from the preliminary engineering drawings and are only suitable for concept level cost estimating purposes by PLS.

Table 12: Water Management Measures - Preliminary Quantity Estimate

Description	Quantity	Unit
Central Pit/Pilgangoora Creek Stage 1 Diversion		
Diversion Earthworks (cut)	45,000	m^3
Diversion Earthworks (fill)	74,000	m^3
Rip-rap at inlet/outlet, 750 mm thick (D_{50} = 450 mm)	500	m^2
Central Pit/Pilgangoora Creek Stage 2 Diversion		
Diversion Earthworks (cut)	64,000	m^3
Diversion Earthworks (fill)	34,000	m^3
Rip-rap at inlet, 750 mm thick (D_{50} = 450 mm)	250	m^2
TMF Stage 2/Pilgangoora Creek Diversion		
Diversion Earthworks (cut)	354,000	m^3
Diversion Earthworks (fill)	612,000	m^3
Rip-rap at inlet/outlet, 750 mm thick (D_{50} = 450 mm)	500	m^2

5.0 CLOSING REMARKS

This Surface Water Management report builds on hydro-meteorological study completed previously and combines the mine planning data for a mining rate of 5 Mtpa to provide concept engineering designs of the works required to protect the proposed mine and associated facilities.

The following surface water tasks were completed as part of this 5 Mtpa study:

- Hydrologic assessment.
- Floodwater and surface water management philosophy and design criteria.
- DFS level design of water management measures - described in the report and presented on preliminary engineering drawings.

The hydrologic and hydraulic calculations required as part of this study have been presented in the Appendices. The accompanying drawings have been completed to a level suitable for inclusion in the Project DFS and may form part of the future detailed engineering design of the Project.

We recommend that detailed hydraulic modelling of all surface water management measures be completed as part of the detailed design of the Project.

We trust that this report satisfies Pilbara Minerals Limited's current requirements and we look forward to discussing the future development of the Project with you.

Groundwater Resource Management Pty Ltd





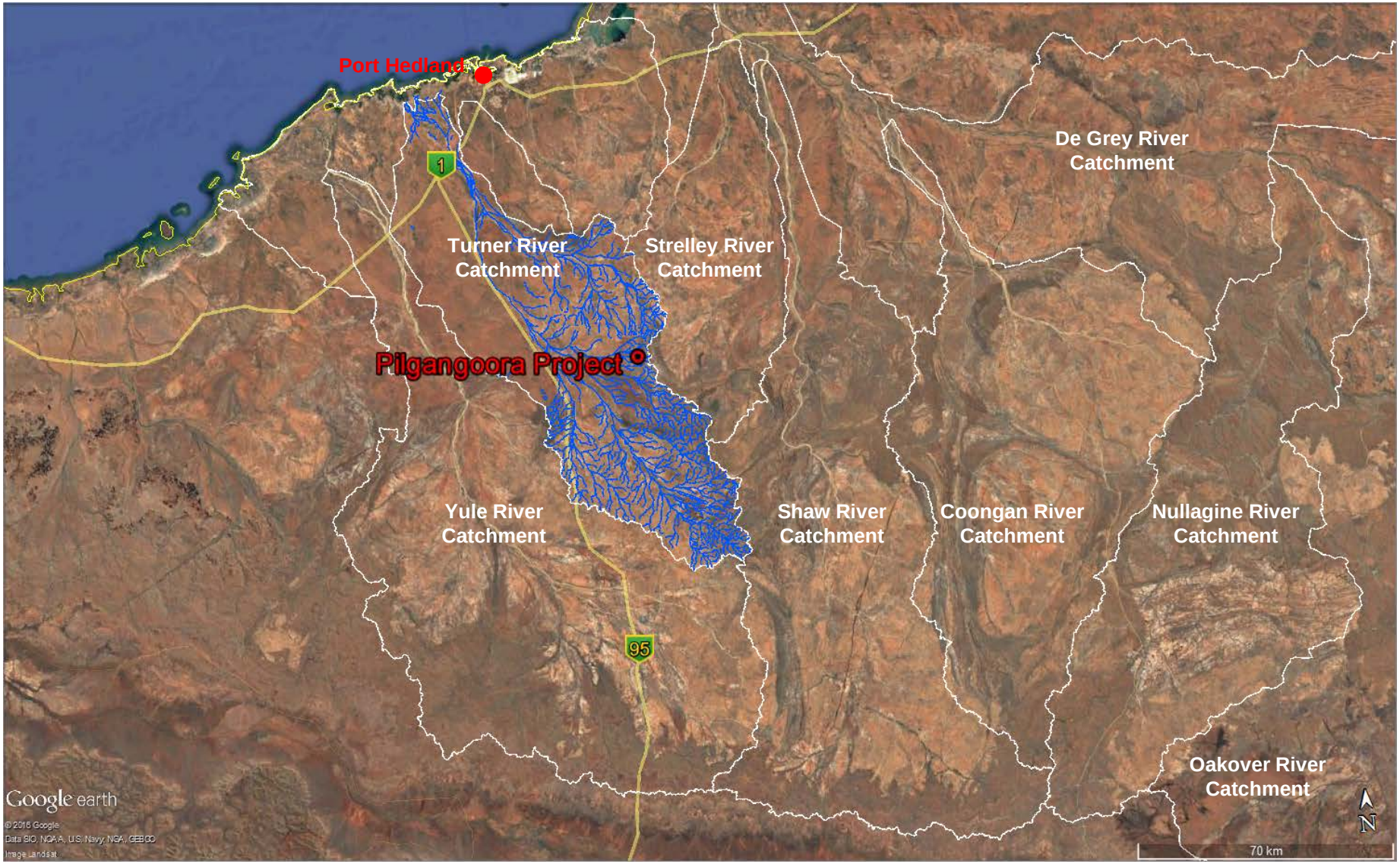
Robin Connolly **Kathy McDougall**

Principal Hydrologist **Principal Hydrogeologist**

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FIGURES



NOTES:

1. Figure not to scale (70 km scale bar provided).
2. Imagery from Google Earth.
3. Catchment Boundaries from Department of Water & Environmental Reregulation (DWER).

J1723R01 – Pilgangoora Project		
Pilbara Minerals Ltd		
AL	Jan 18	**FIGURE 1**

Pilgangoora Project Location & DWER Regional Catchment Boundaries

GROUNDWATER RESOURCE MANAGEMENT

DRAWINGS

STRELLEY RIVER/
TURNER RIVER
CATCHMENT DIVIDE

TURNER RIVER EAST
CATCHMENT
28.463 km²

NORTHERN CREEK CATCHMENT
26.403 km² (EXC. HOUSTON &
PILGANGOORA CREEK CATCHMENTS)

PROPOSED 5 Mtpa PROJECT
FACILITIES (TYP.)

HOUSTON CREEK
CATCHMENT
17.553 km²

PILGANGOORA CREEK
CATCHMENT
18.126 km²

SOUTHERN CREEK
CATCHMENT
18.844 km2

CHINNAMON CREEK CATCHMENT 368.470 km²
(INCLUDING NORTHERN, HOUSTON, PILGANGOORA
& SOUTHERN CREEK CATCHMENTS)

TURNER RIVER
CATCHMENT

STRELLEY RIVER
CATCHMENT

STRELLEY RIVER/
TURNER RIVER
CATCHMENT DIVIDE

NOTES:
1. COORDINATES TO GDA94 MGA ZONE 50 NORTH.
2. ELEVATIONS TO AUSTRALIAN HEIGHT DATUM (AHD).
3. TOPOGRAPHICAL BACKGROUND MAP AND WATERCOURSE SHAPES FROM GEOSCIENCE AUSTRALIA 250K TOPO DATASET.
4. CATCHMENT BOUNDARIES FROM BUREAU OF METEOROLOGY AUSTRALIAN HYDROLOGICAL GEOSPATIAL FABRIC DATASET (V2.1, FEB 2013)

REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
A	ISSUED FOR CLIENT REVIEW	ARL	22/01/18	–	–
		CHECKED		APPROVED	

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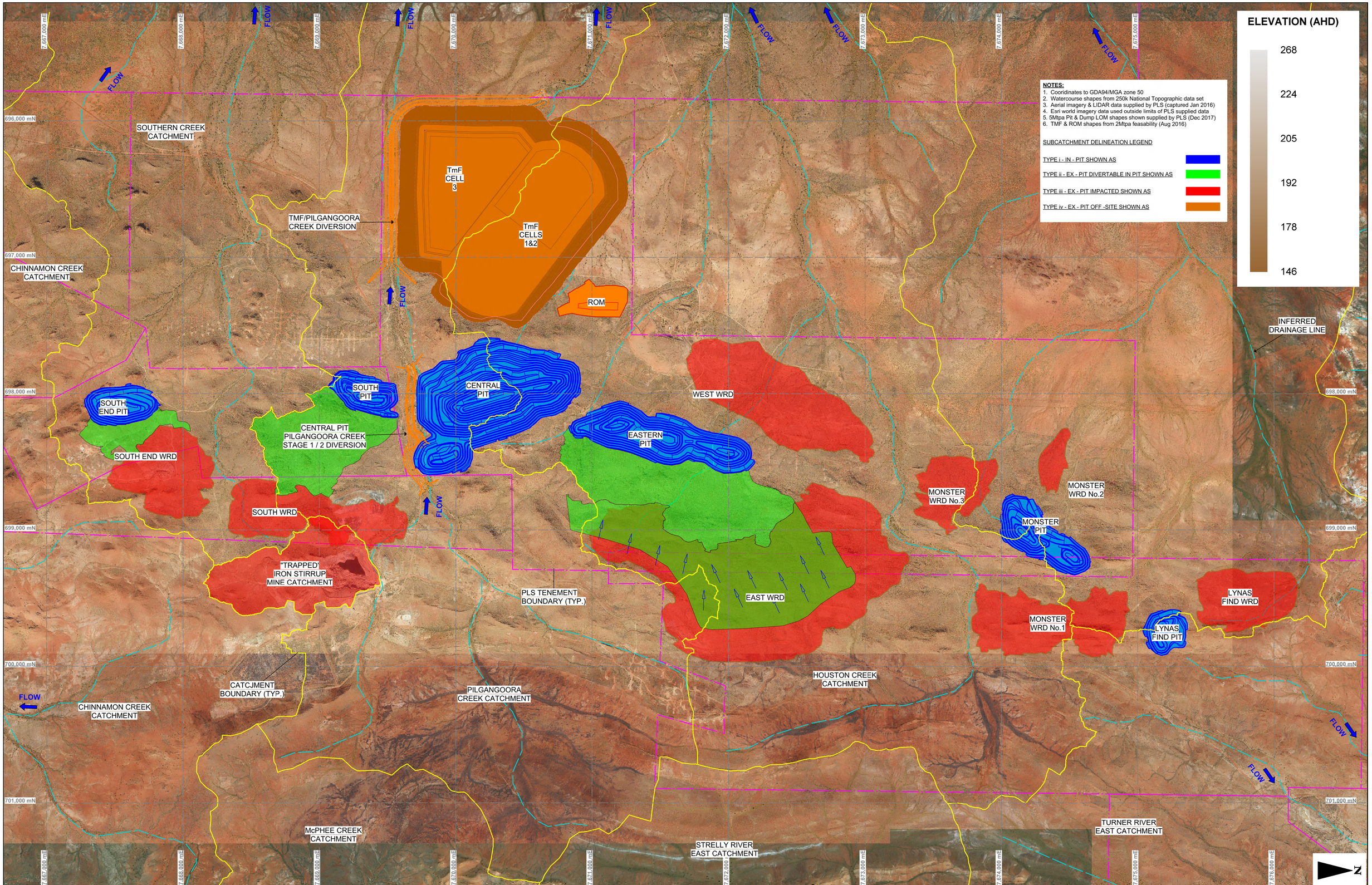
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DESIGNED	ARL 15 DEC 2017
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SCALE	1:80,000 @ A1
PROJECT	PILGANGOORA LITHIUM–TANTALITE PROJECT
DRAWING TITLE	5 Mtpa PFS REGIONAL CATCHMENT DELINEATION
PROJECT No	J1723
DWG. No.	D01
	A

A1



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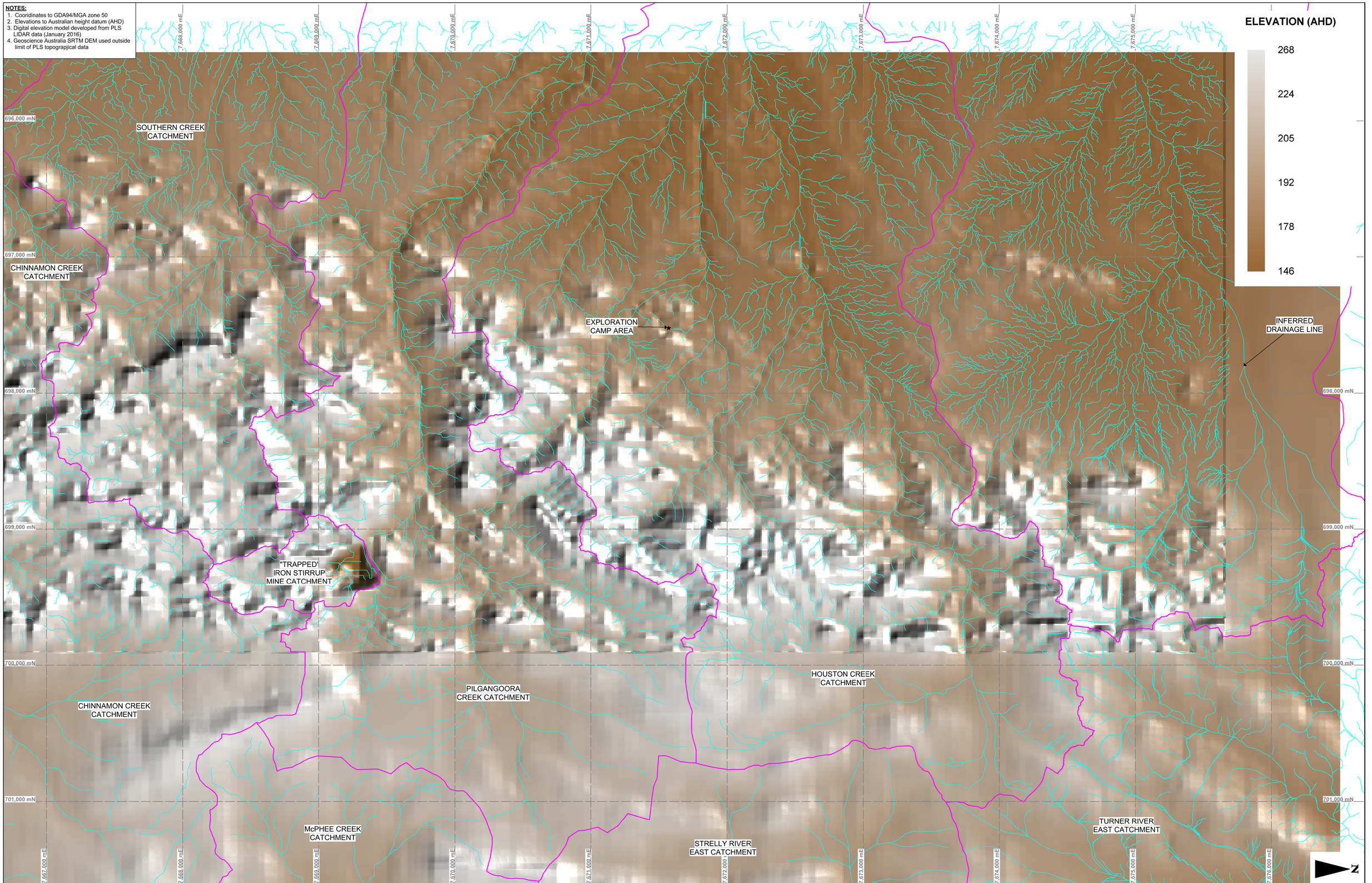
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DRAWN: BN	DATE: 17 Jul 2018	DRAWING CHECK / DATE	DRAWING TITTLE: 5 Mtpa DFS LOCAL CATCHMENT DELINEATION & LOM WATER MANAGEMENT PLAN
DESIGNED: ARL	DATE: 15 DEC 2017	DESIGN CHECK / DATE	
AUTHORISED / DATE	SCALE: 1:12,500 @ A1	PROJECT No: J1723	DWG. No. D02 — A1

NOTES:
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2. Elevations to Australian height datum (AHD)
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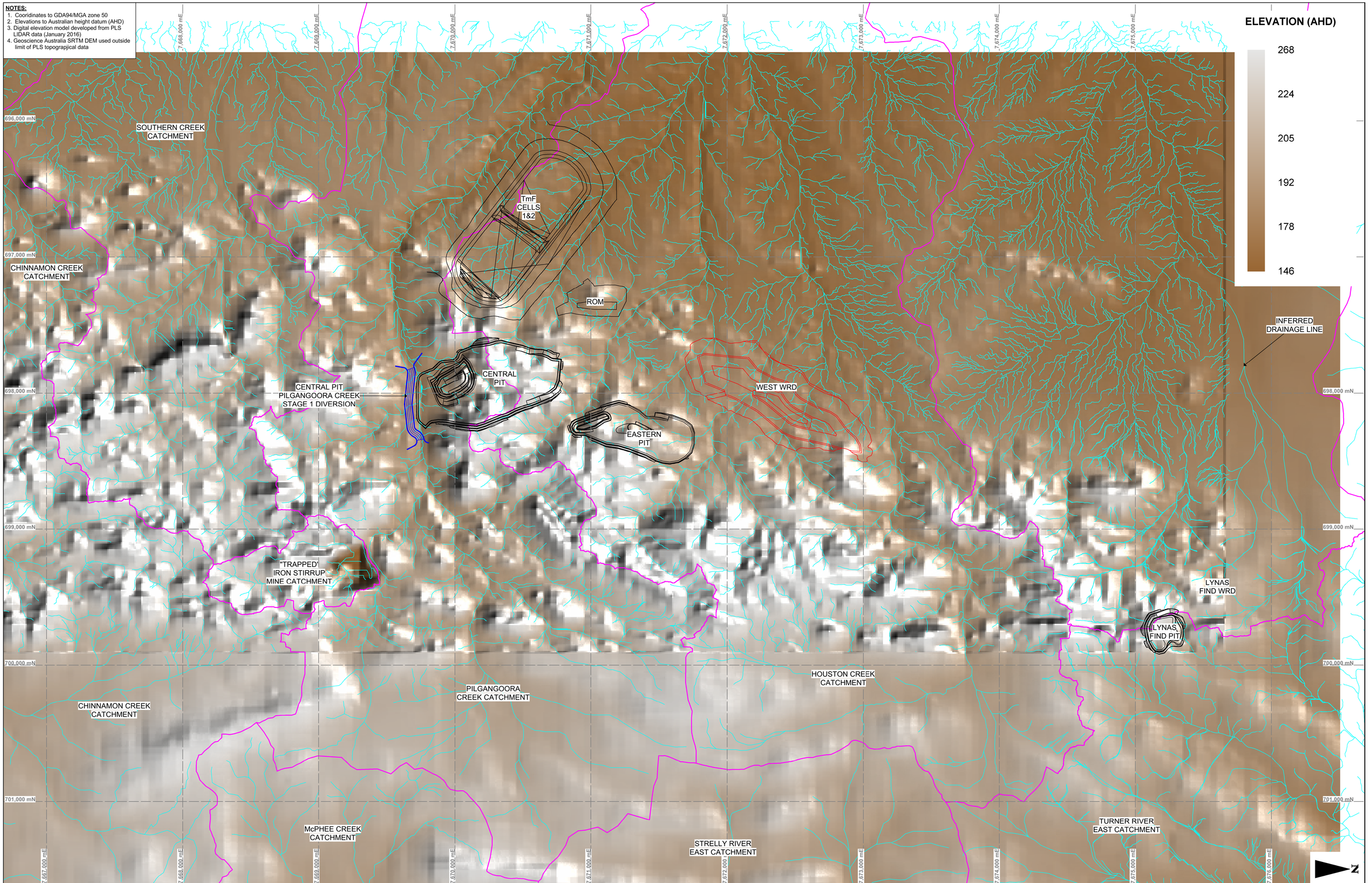
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DRAWN	BN	DATE 17 Jul 2018	DRAWING CHECK / DATE
DESIGNED	ARL	DATE 15 DEC 2017	DESIGN CHECK / DATE
AUTHORISED		DATE	SCALE 1:12,500 @ A1

PROJECT	PILGANGOORA LITHIUM - TANTALUM PROJECT		
DRAWING TITTLE	5 Mtpa DFS PILGANGOORA MINING AREA YEAR 0 FACILITY PLAN		
PROJECT No	J1723	DWG. No. D03	A1

NOTES:

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2. Elevations to Australian height datum (AHD)
3. Digital elevation model developed from PLS LIDAR data (January 2016)
4. Geoscience Australia SRTM DEM used outside limit of PLS topograpjical data



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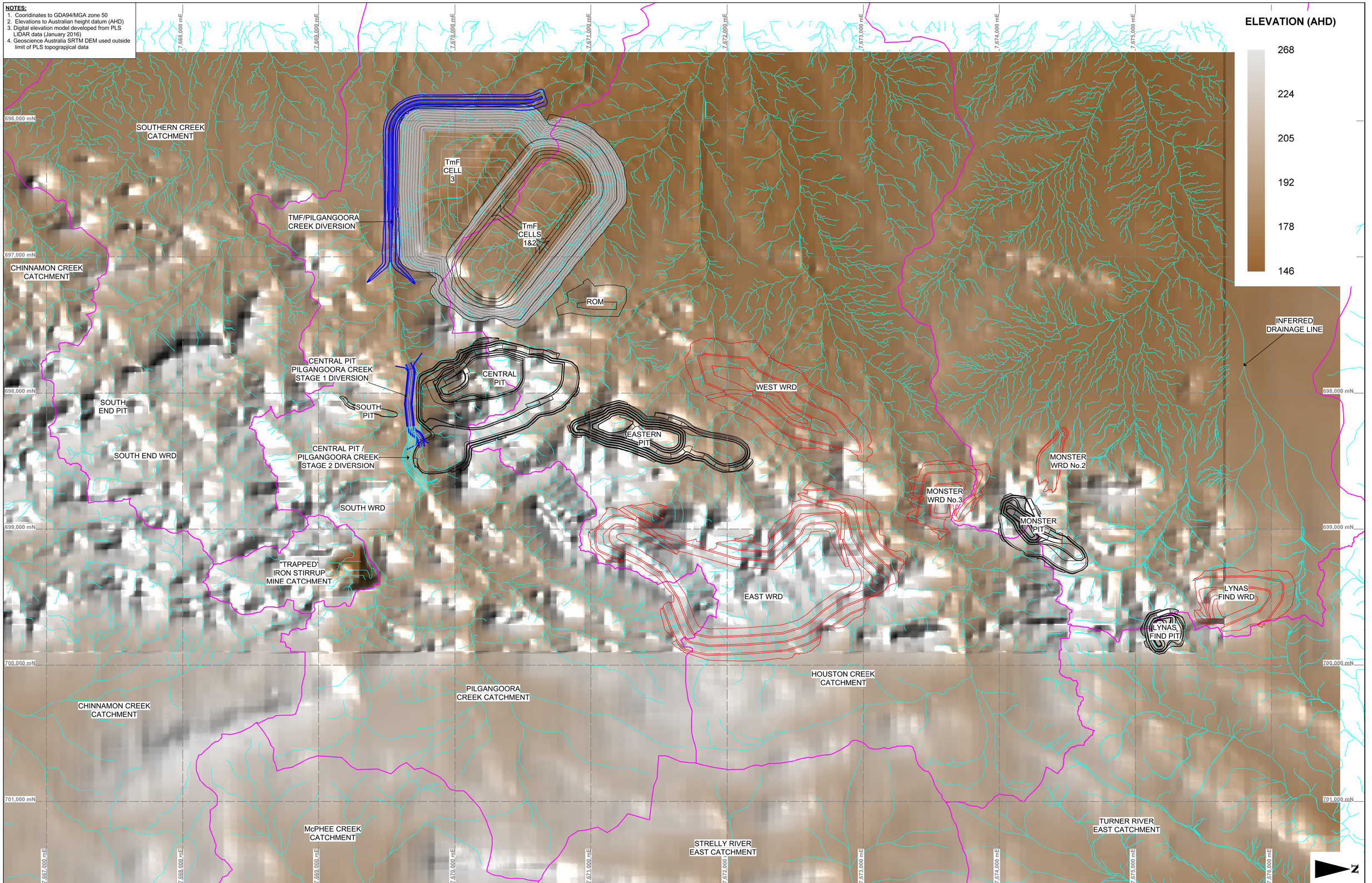
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DRAWN	BN	DATE 17 Jul 2018	DRAWING CHECK / DATE
DESIGNED	ARL	DATE 15 DEC 2017	DESIGN CHECK / DATE
AUTHORISED / DATE	SCALE 1:80,000 @ A1		

PROJECT	PILGANGOORA LITHIUM - TANTALUM PROJECT		
DRAWING TITTLE	5 Mtpa DFS PILGANGOORA MINING AREA YEAR 5 FACILITY PLAN		
PROJECT No	J1723	DWG. No. D04	A1

NOTES:

1. Cooridinates to GDA94/MGA zone 50
2. Elevations to Australian height datum (AHD)
3. Digital elevation model developed from PLS LIDAR data (January 2016)
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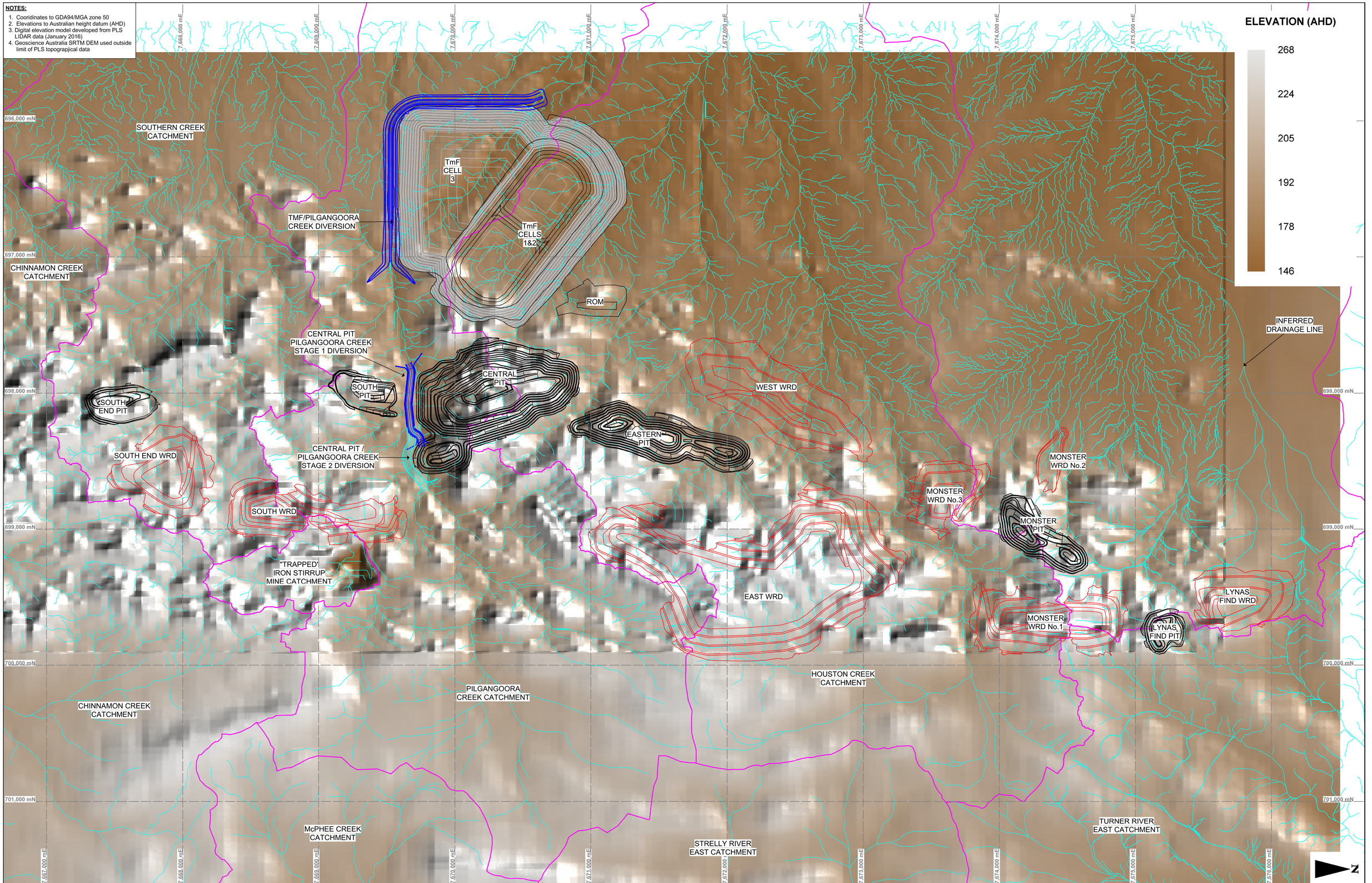
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CLIENT	PILBARA MINERALS LIMITED		
DRAWN	BN	DATE 17 Jul 2018	DRAWING CHECK / DATE
DESIGNED	ARL	DATE 23 JAN 2018	DESIGN CHECK / DATE
AUTHORISED		DATE	SCALE 1:12,500 @ A1

PROJECT	PILGANGOORA LITHIUM - TANTALUM PROJECT		
DRAWING TITTLE	5 Mtpa DFS PILGANGOORA MINING AREA YEAR 10 FACILITY PLAN		
PROJECT No	J1723	DWG. No. D05	A1

NOTES:

1. Cooridinates to GDA94/MGA zone 50
2. Elevations to Australian height datum (AHD)
3. Digital elevation model developed from PLS LIDAR data (January 2016)
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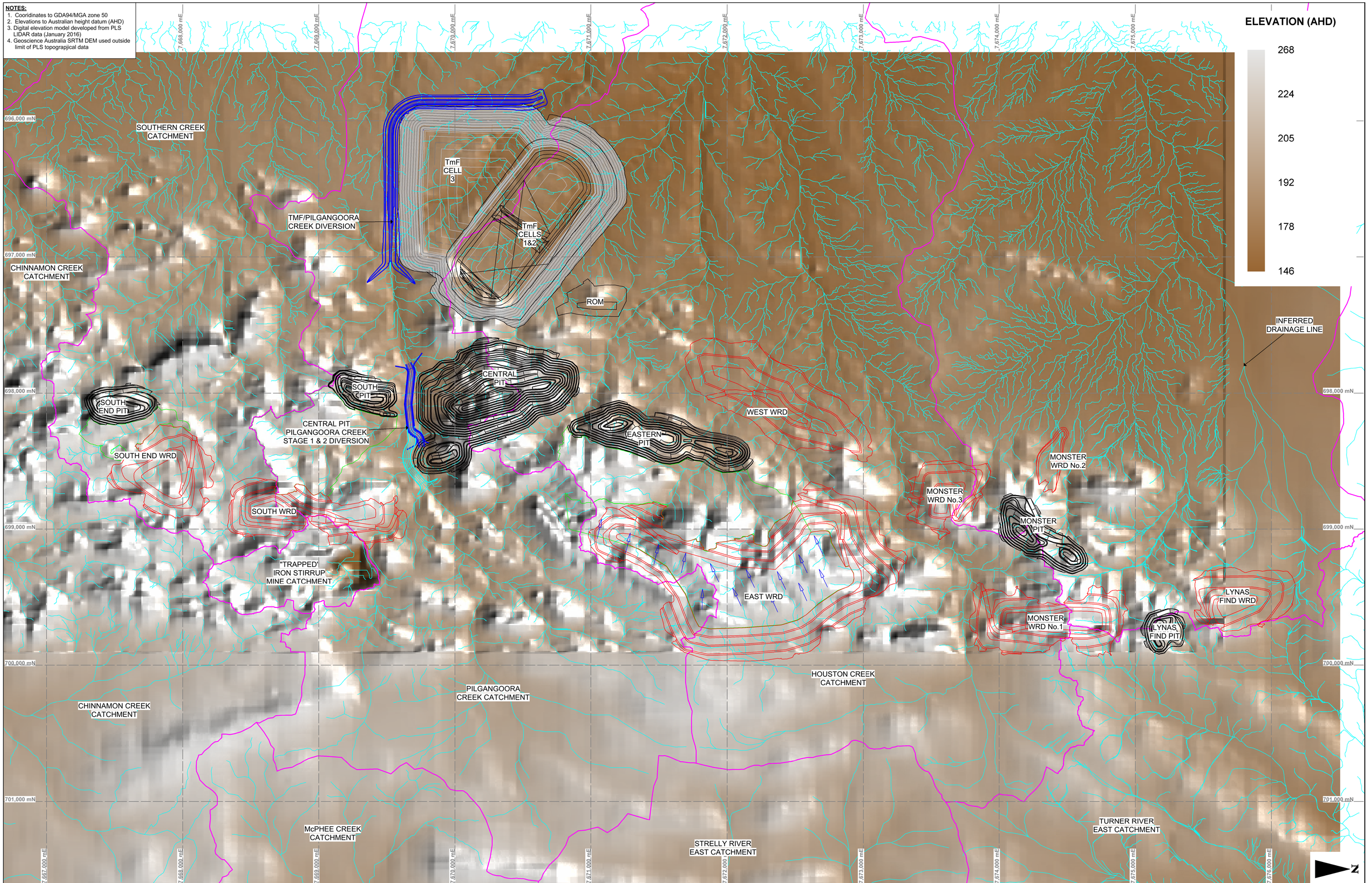
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CLIENT	PILBARA MINERALS LIMITED		
DRAWN	BN	DATE 17 Jul 2018	DRAWING CHECK / DATE
DESIGNED	ARL	DATE 23 JAN 2018	DESIGN CHECK / DATE
AUTHORISED		DATE	SCALE 1:12,500 @ A1

PROJECT	PILGANGOORA LITHIUM - TANTALUM PROJECT		
DRAWING TITTLE	5 Mtpa DFS PILGANGOORA MINING AREA YEAR 15 FACILITY PLAN		
PROJECT No	J1723	DWG. No. D06	A1

NOTES:

1. Coordinates to GDA94/MGA zone 50
2. Elevations to Australian height datum (AHD)
3. Digital elevation model developed from PLS LIDAR data (January 2016)
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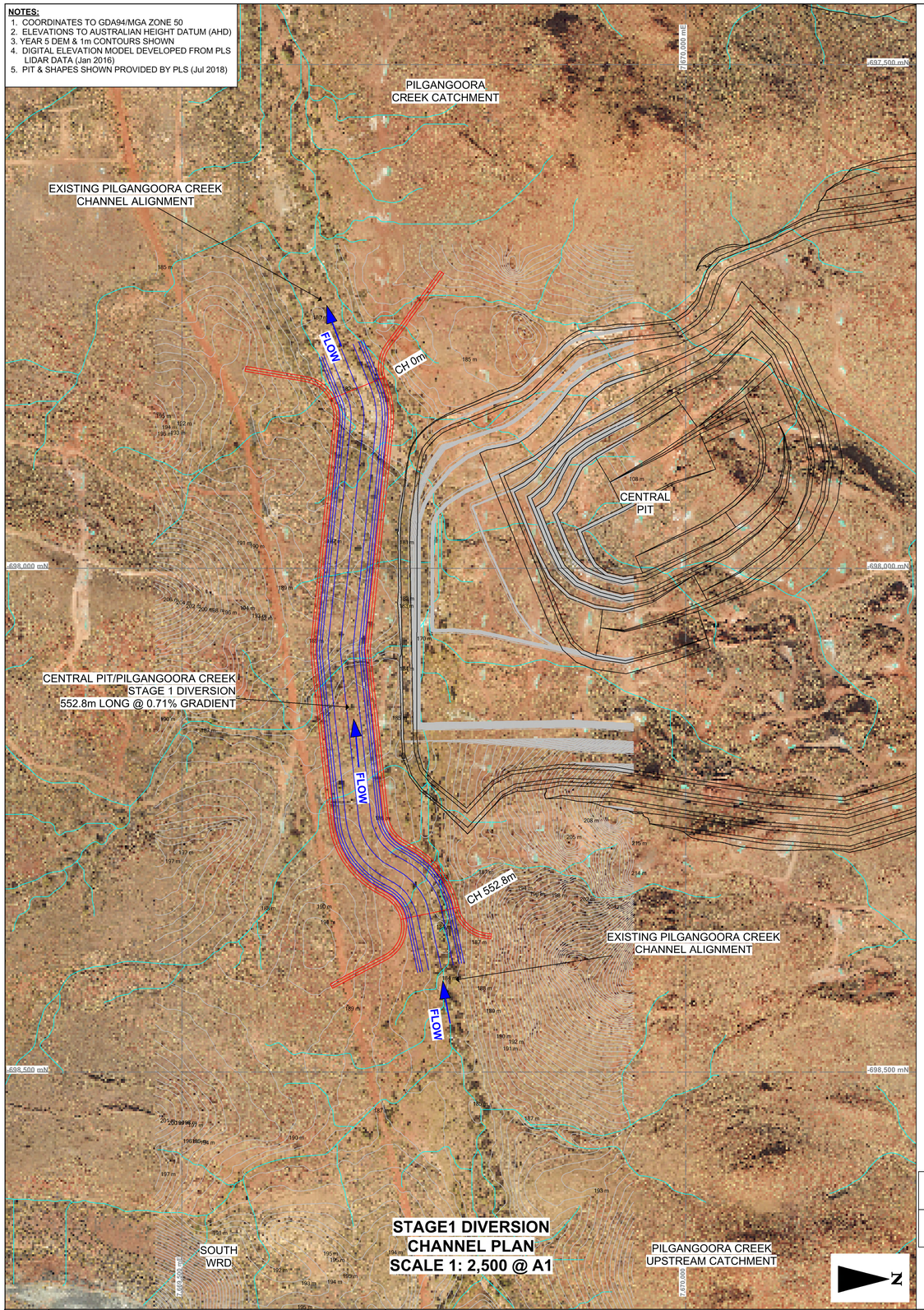
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CLIENT	PILBARA MINERALS LIMITED		
DRAWN	BN	DATE 17 Jul 2018	DRAWING CHECK / DATE
DESIGNED	ARL	DATE 23 JAN 2018	DESIGN CHECK / DATE
AUTHORISED / DATE		SCALE	1:12,500 @ A1

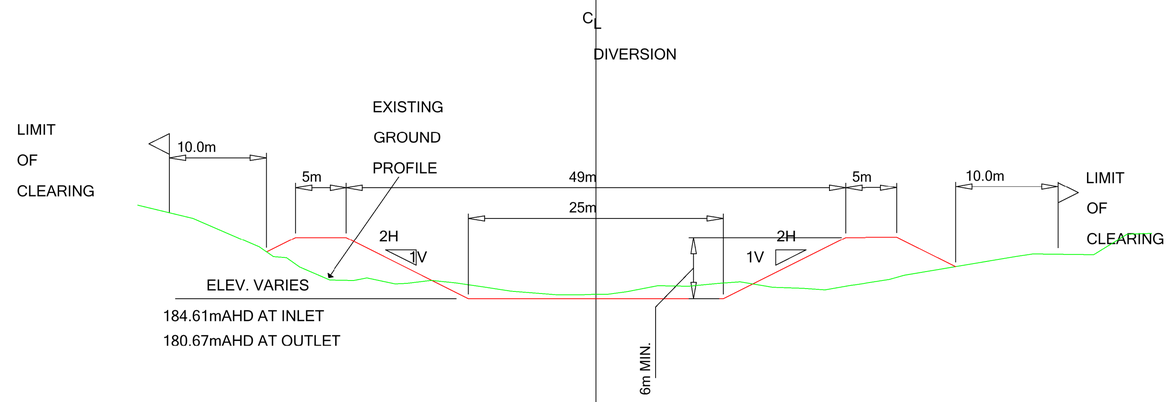
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DRAWING TITTLE	5 Mtpa DFS PILGANGOORA MINING AREA YEAR 18 FACILITY PLAN		
PROJECT No	J1723	DWG. No. D07	A1

NOTES:

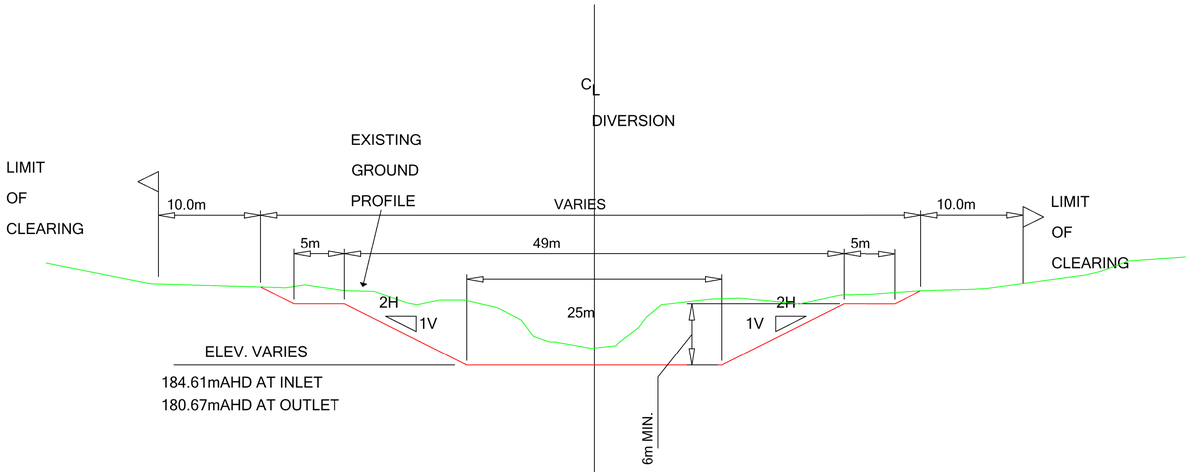
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2. ELEVATIONS TO AUSTRALIAN HEIGHT DATUM (AHD)
3. YEAR 5 DEM & 1m CONTOURS SHOWN
4. DIGITAL ELEVATION MODEL DEVELOPED FROM PLS LIDAR DATA (Jan 2016)
5. PIT & SHAPES SHOWN PROVIDED BY PLS (Jul 2018)



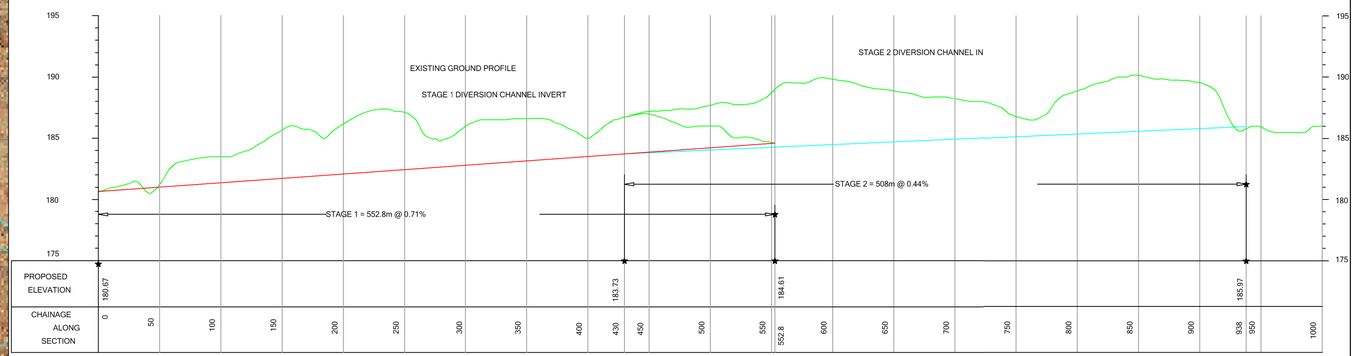
STAGE1 DIVERSION CHANNEL PLAN
SCALE 1: 2,500 @ A1



DIVERSION CHANNEL TYPICAL SECTION IN FILL
SCALE 1:300 @ a1



DIVERSION CHANNEL TYPICAL SECTION IN CUT
SCALE 1:300 @ a1



LONGITUDINAL PROFILE ALONG STAGE 1 & 2 DIVERSION CHANNEL
SCALE HORIZ. 1:2,500@A1 VERT. 1:250@A1
N.B. 10X VERTICAL EXAGGERATION

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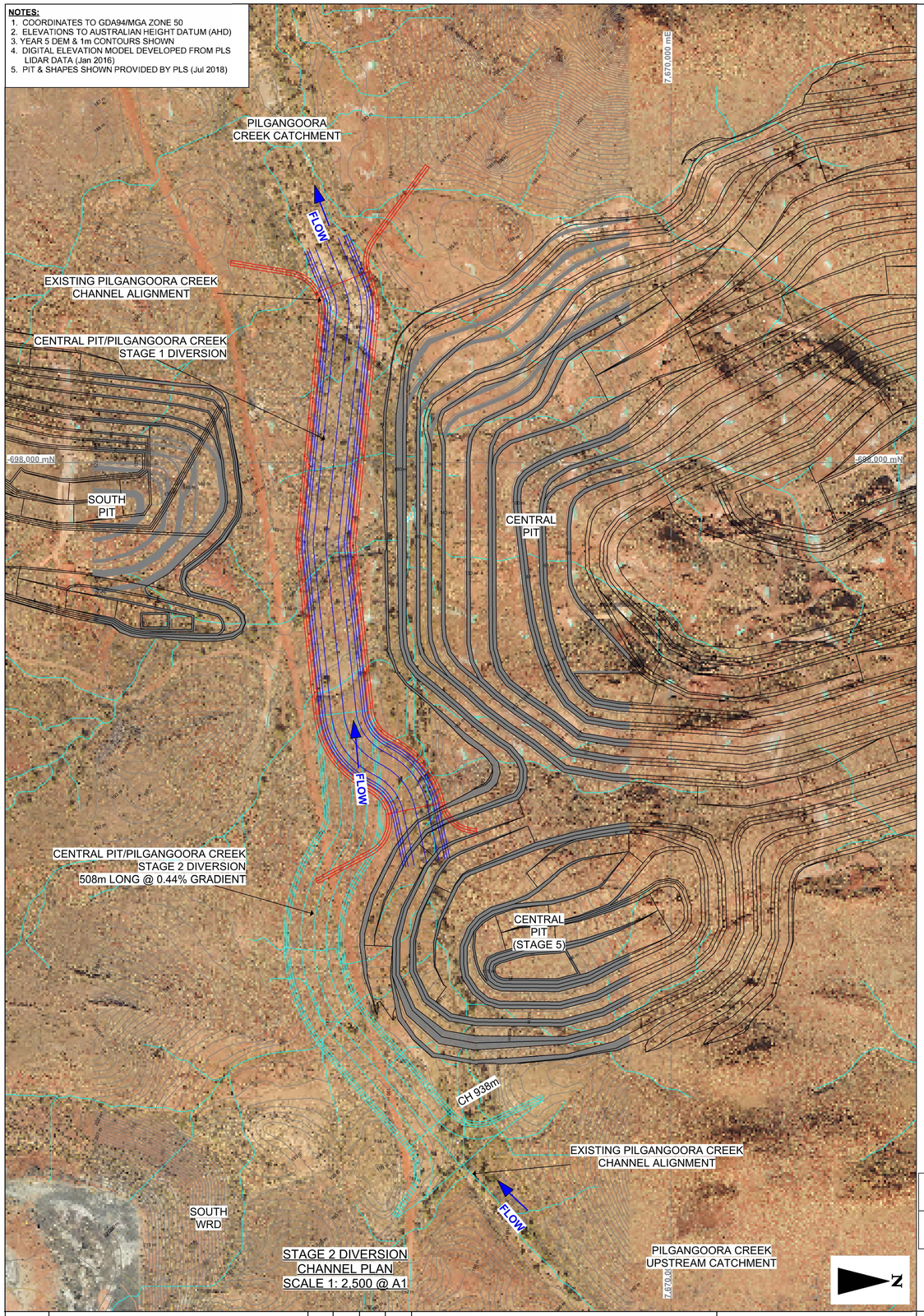
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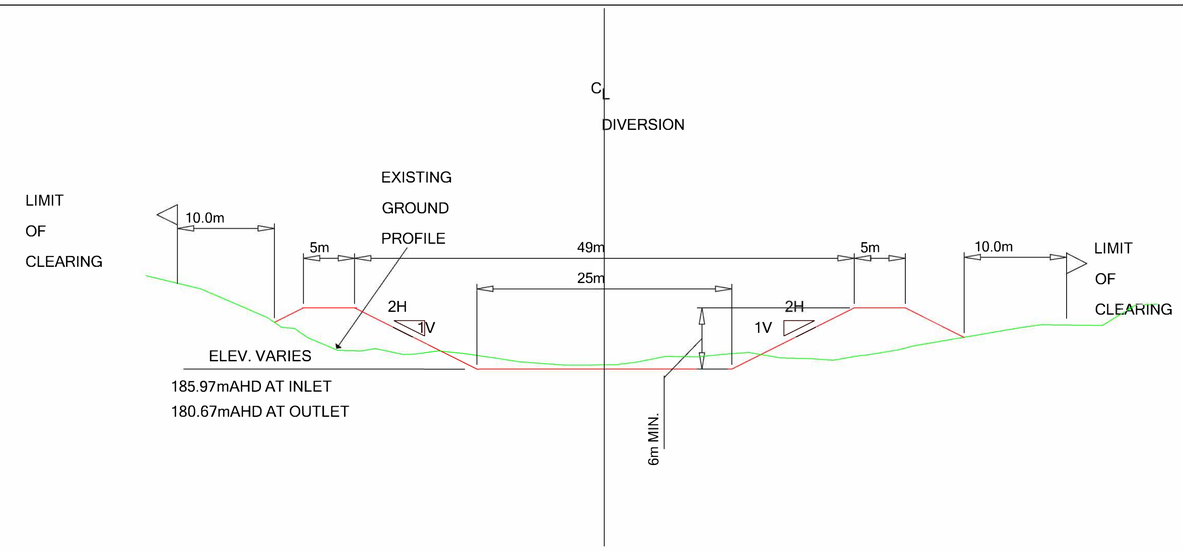
GROUNDWATER RESOURCE MANAGEMENT

CLIENT	PILBARA MINERALS LIMITED	PROJECT	PILGANGOORA LITHIUM - TANTALUM PROJECT
DRAWN BN	DATE 17 Jul 2018	DRAWING CHECK	DATE
DESIGNED ARL	DATE 15 DEC 2017	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE AS SHOWN	
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PROJECT No J1723	DWG. No. D08	A1	

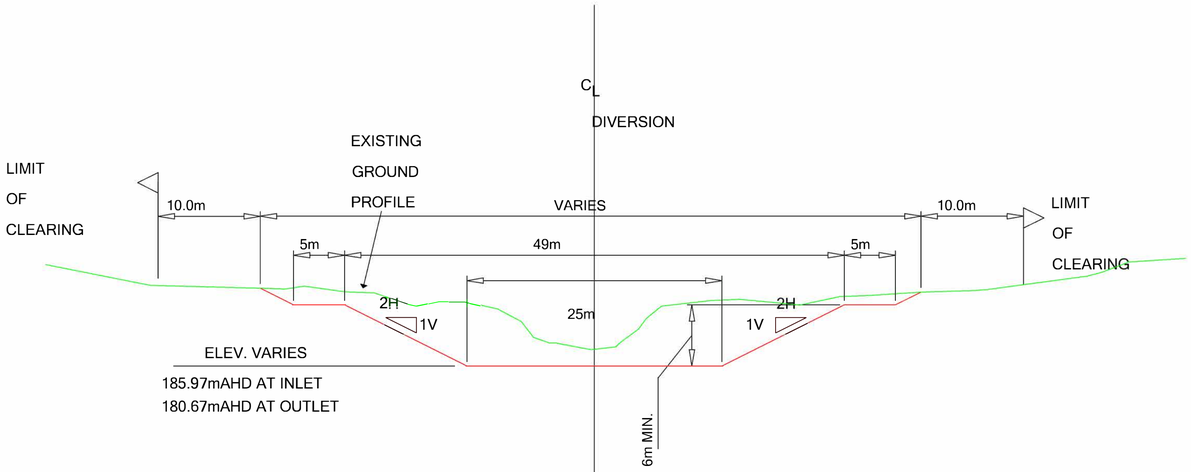
NOTES:

1. COORDINATES TO GDA94/MGA ZONE 50
2. ELEVATIONS TO AUSTRALIAN HEIGHT DATUM (AHD)
3. YEAR 5 DEM & 1m CONTOURS SHOWN
4. DIGITAL ELEVATION MODEL DEVELOPED FROM PLS LIDAR DATA (Jan 2016)
5. PIT & SHAPES SHOWN PROVIDED BY PLS (Jul 2018)

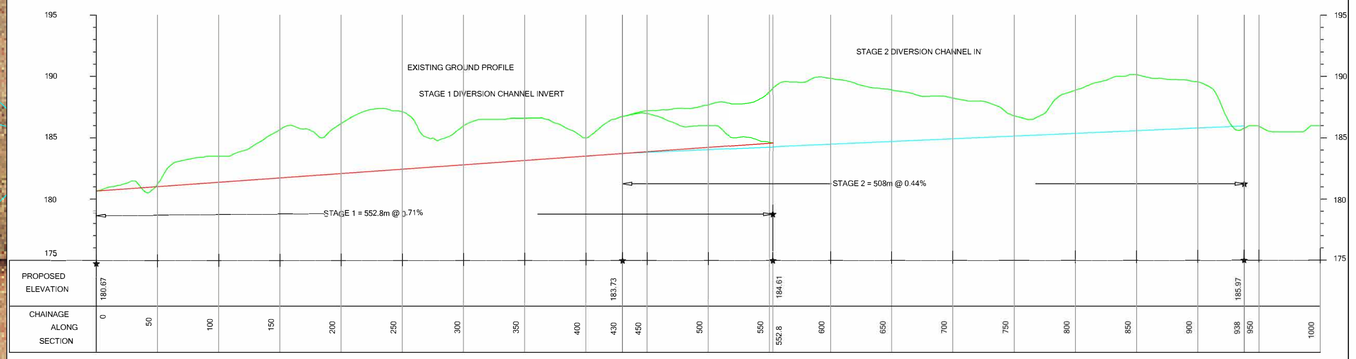




DIVERSION CHANNEL TYPICAL SECTION IN FILL
SCALE 1:300 @ a1



DIVERSION CHANNEL TYPICAL SECTION IN CUT
SCALE 1:300 @ a1



LONGITUDINAL PROFILE ALONG STAGE 1 & 2 DIVERSION CHANNEL
SCALE HORIZ. 1:2,500@A1 VERT. 1:250@A1
N.B. 10X VERTICAL EXAGGERATION

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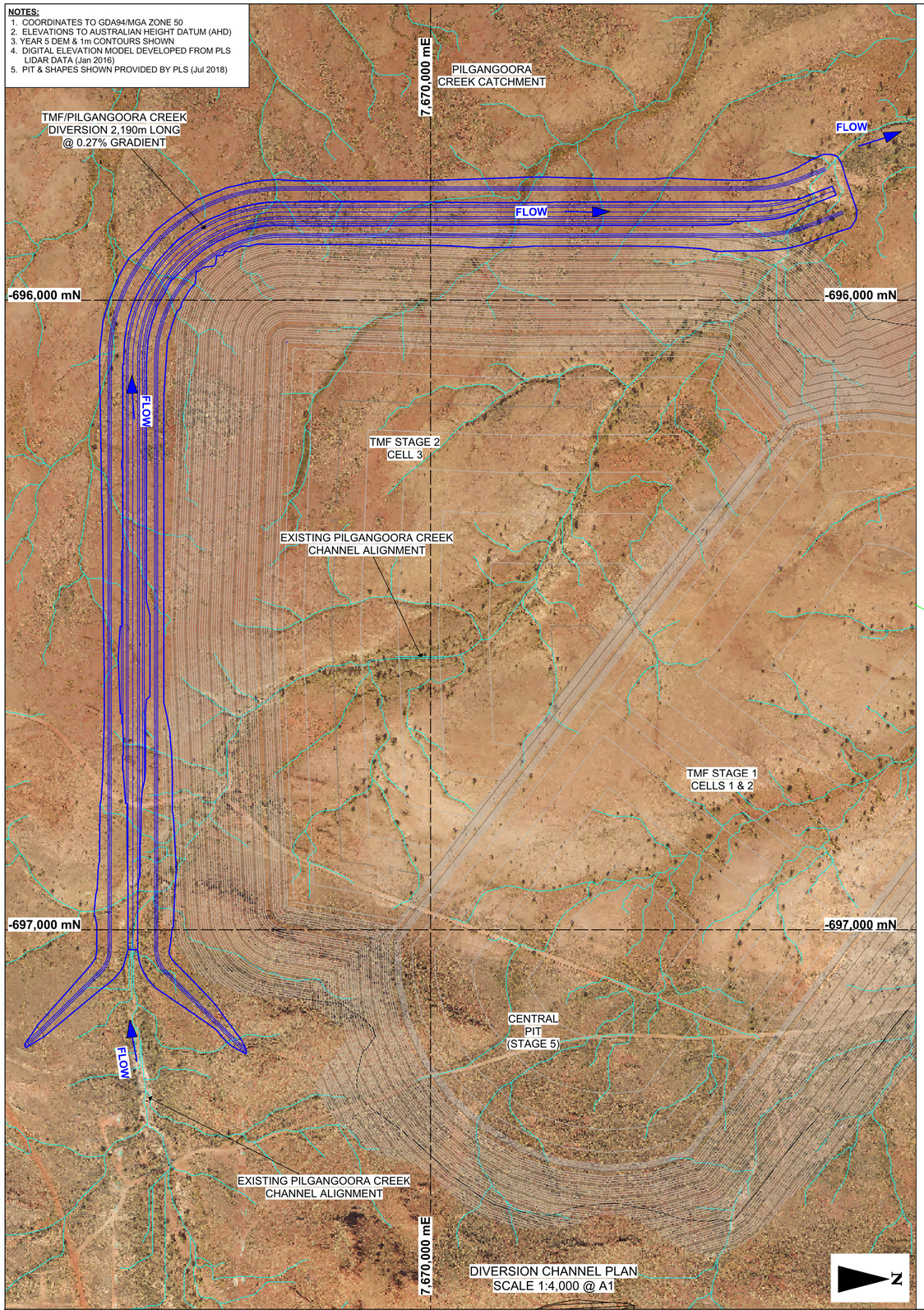
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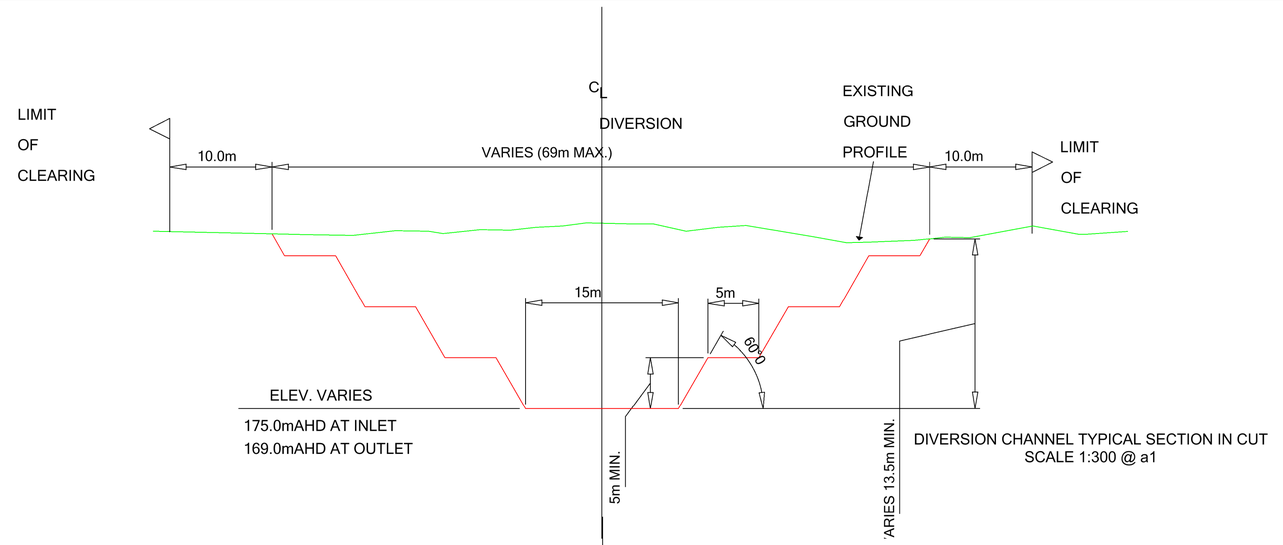
GROUNDWATER RESOURCE MANAGEMENT

CLIENT	PILBARA MINERALS LIMITED		PROJECT: PILGANGOORA LITHIUM - TANTALUM PROJECT
DRAWN: BN	DATE: 17 Jul 2018	DRAWING CHECK / DATE	DRAWING TITTLE: 5 Mtpa DFS CENTRAL PIT/PILGANGOORA CREEK STAGE 2 DIVERSION
DESIGNED: ARL	DATE: 15 DEC 2017	DESIGN CHECK / DATE	
AUTHORISED / DATE	SCALE: AS SHOWN	PROJECT No: J1723	DWG. No. D09 — A1

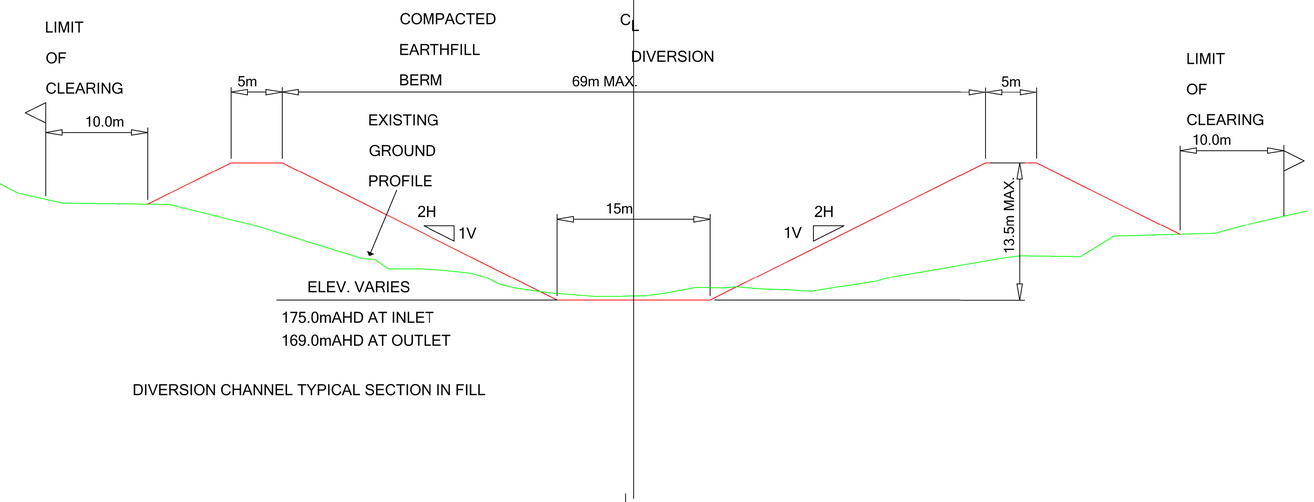
NOTES:
1. COORDINATES TO GDA94/MGA ZONE 50
2. ELEVATIONS TO AUSTRALIAN HEIGHT DATUM (AHD)
3. YEAR 5 DEM & 1m CONTOURS SHOWN
4. DIGITAL ELEVATION MODEL DEVELOPED FROM PLS LIDAR DATA (Jan 2016)
5. PIT & SHAPES SHOWN PROVIDED BY PLS (Jul 2018)



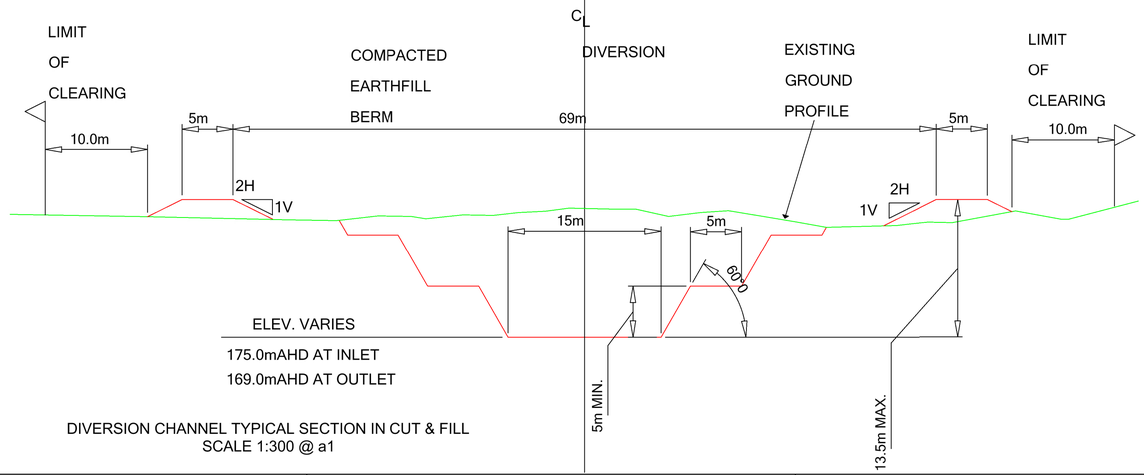
DIVERSION CHANNEL PLAN
SCALE 1:4,000 @ A1



DIVERSION CHANNEL TYPICAL SECTION IN CUT
SCALE 1:300 @ a1



DIVERSION CHANNEL TYPICAL SECTION IN FILL



DIVERSION CHANNEL TYPICAL SECTION IN CUT & FILL
SCALE 1:300 @ a1

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DRAWN BN	DATE 17 Jul 2018	DRAWING CHECK	DATE
DESIGNED ARL	DATE 15 DEC 2017	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE AS SHOWN	DRAWING TITTLE: 5 Mtpa DFS TMF STAGE 2/PILGANGOORA CREEK DIVERSION
PROJECT No J1723	DWG. No. D10	A1	

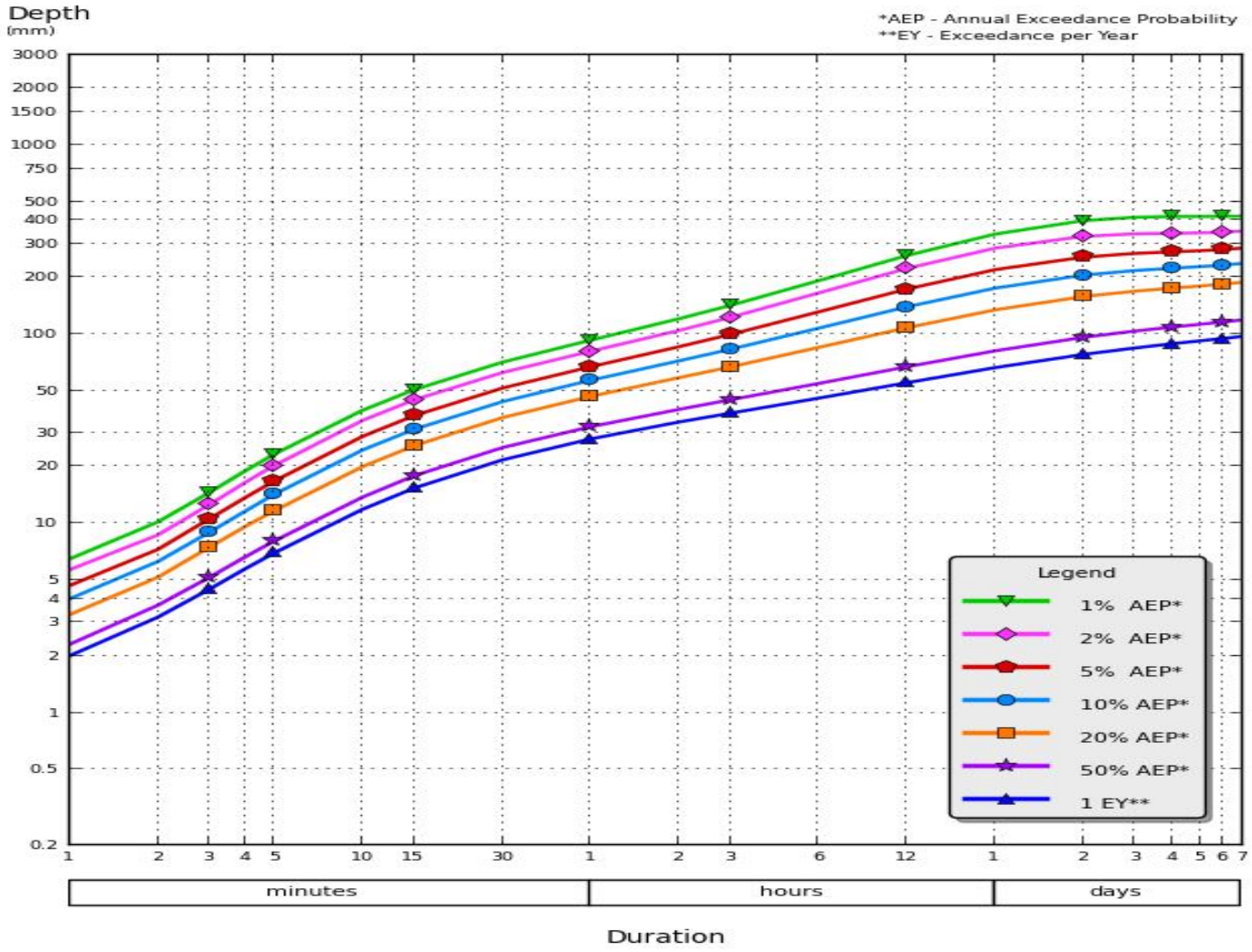
APPENDIX A

Intensity Frequency Duration Relationship & PMP/PMF Estimates for Pilgangoora Project Site

IFD Design Rainfall Depth (mm)

Issued: 18 February 2016

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).



J160002 – Pilgangoora Project		**Appendix B Rainfall Intensity-Frequency-Duration Relationship Chart**
Pilbara Minerals Ltd		
AL	Feb 16	**FIGURE B1**

GROUNDWATER RESOURCE MANAGEMENT

IFD Design Rainfall Depth (mm)

Issued: 18 February 2016

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).

	EY	Annual Exceedance Probability (AEP)					
Duration	**1EY**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
1 min	2.0	2.3	3.3	4.0	4.7	5.7	6.5
2 min	3.2	3.7	5.2	6.3	7.3	8.7	10.2
3 min	4.5	5.2	7.5	9.0	10.6	12.6	14.6
4 min	5.8	6.7	9.7	11.7	13.8	16.6	19.1
5 min	7.0	8.1	11.7	14.3	16.8	20.3	23.3
6 min	8.2	9.5	13.7	16.6	19.7	23.8	27.1
10 min	11.9	13.8	20.0	24.5	28.9	35.1	39.7
15 min	15.4	17.9	25.8	31.5	37.2	45.1	51.0
30 min	21.7	25.2	36.3	44.1	52.0	62.8	71.3
1 hour	28.0	32.5	47.0	57.2	67.4	81.4	93.2
2 hour	34.4	40.1	59.0	72.4	86.0	104.8	120.9
3 hour	38.3	45.1	67.3	83.4	99.9	123.0	142.3
6 hour	46.0	55.0	85.3	107.8	131.5	165.5	192.2
12 hour	55.5	67.4	108.4	139.8	173.5	223.1	261.1
24 hour	66.7	81.8	134.7	175.5	219.8	285.5	338.9
48 hour	78.3	96.4	158.4	205.6	255.9	329.4	399.0
72 hour	84.7	104.1	169.1	217.3	267.8	339.9	415.7
96 hour	89.1	109.1	175.4	223.5	273.0	342.4	419.6
120 hour	92.4	113.0	180.1	228.0	276.6	343.8	419.9
144 hour	95.1	116.2	184.4	232.4	280.7	346.7	420.1
168 hour	97.6	119.3	188.7	237.2	285.8	351.7	421.5

J160002 – Pilgangoora Project			**Appendix B Rainfall Intensity-Frequency-Duration Relationship Table**
Pilbara Minerals Ltd			
AL	Feb 16	**FIGURE B2**	

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GROUNDWATER RESOURCE MANAGEMENT

MEMORANDUM

From: Alistair Lowry	Date: 13 January 2017	Project: J160002
To: Garry Plowright, Keith Lindbeck	Company: Pilbara Minerals Ltd.	
Re: Pilgangoora Lithium-Tantalum Project – Probable Maximum Precipitation & Probable Maximum Flood Estimation		

Introduction

This memorandum has been prepared to support the Pilgangoora Project Mine Closure Plan (MCP) which is currently being prepared by others. It is understood that the regulatory authorities require an assessment of the proposed project closure landforms and facilities under Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) conditions. In particular an assessment of the PMP/PMF event impacts on "TSF design criteria, surface water management structures (diversions, flood protection bunds etc.) and pit hydrology modelling"[1] should be completed for post-closure conditions.

The estimation of the PMP/PMF event for the Pilgangoora site has therefore been presented in the following sections and its impacts on the post-closure landforms and facilities have been identified and quantified where possible.

This memorandum builds on the hydrological information presented previously in the following GRM reports:

- Hydro-meteorological desktop study (GRM report J160002R01);
- Surface water management assessment (GRM report J160002R02);
- Site water balance modelling (GRM letter report J160002L02); and
- Pit lake closure modelling (GRM letter report J160002L03b).

It is assumed that the reader is familiar with the content and findings of these earlier reports.

Background

At the outset it should be noted that the PMP has been defined by the World Meteorological Organisation as the "greatest depth of precipitation for a given duration, meteorologically possible for a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends"[2]. It is a *conceptual event* based around the hypothesis that the rainfall results from the simultaneous occurrence of a storm of optimal efficiency together with maximum moisture availability which is approximated by assuming

[1] Email from Rob Irwin (DMP Environmental Officer) to Garry Plowright, 12 December 2016.
[2] "*Manual for Estimation of Probable Maximum Precipitation"* Operational Hydrology Report No. 1, 2nd Edition (World Meteorological Organization, 1986).

maximum moisture inflow to the storm. As such, it can be thought of as an *upper limit* ***estimate*** of the rainfall depth that could occur in the future. The PMP is a key design rainfall input, along with spatial and temporal distributions and other factors, to the calculation of the PMF which is often used as the design flood event for large dams and for other sensitive water management works and floodplain management studies.

A number of different methods have been used historically in Australia for PMP estimation including the in-situ maximisation of data recorded at a specific location and also storm transposition methods which allowed the displacement of a storm from the location where it occurred to a target location assuming the storm could just as likely have occurred there. However since the mid 1970's generalised methods have been developed that allow rainfall from much wider geographical regions to be analysed and these are generally considered to be an improvement over the earlier transposition methods.

Successive revisions of these generalised methods have, in turn, brought progressively higher estimates of PMP depths for individual catchments as each revision has utilised a greater amount of data and better analytical techniques. Currently the Generalised Short Duration Method (GSDM[3], also known as the "Thunderstorm Method") is used to derive PMP estimates for durations less than six hours across all of Australia, while the Revised Generalised Tropical Storm Method (GTSMR[4]) is used for longer duration events and covers the majority of continental Australia affected by tropical storms. The Generalised Southeast Australia Method (GSAM) is used for longer-duration PMP estimates in south-east Australia.

Although, the WMO definition of PMP relates to the "theoretical" greatest rainfall depth of precipitation for a given duration that is physically possible, it is recognised that limitations in data and understanding of extreme meteorological conditions means that there is a finite probability, albeit small, of the PMP estimate being exceeded. In order to take into consideration the inability to accurately estimate the theoretical upper limit of rainfall, the term "*operational estimate of the PMP"* has been adopted[5]. This represents the best estimate of the PMP depth for a particular location that can currently be made using information obtained from observed large events and the generalised PMP methods. Therefore, it should be noted that the GSDM and GTSMR PMP estimates presented in this memorandum are the *operational estimates* of the PMP as opposed to the theoretical PMP. This distinction acknowledges the finite probability of occurrence of the PMP as discussed above.

The average recurrence interval (ARI) or annual exceedance probability (AEP) of the PMP is uncertain and results in much debate within the field of hydrology. However, it is considered to be an extremely rare event of at least 100,000 to 1 million year ARI (i.e. 0.001% to 0.0001% AEP). The PMF is considered to be an even more extreme event as it not only requires the PMP to occur, but also needs the most severe antecedent moisture and other hydrological conditions to prevail. Consequently the PMF is generally considered to be one or two orders of magnitude greater than the PMP (i.e. at least 1 million to 10 million year ARI or 0.0001% to 0.00001% AEP).

The application of the GSDM and GTSMR generalised methods to the Pilgangoora site to obtain an operational estimate of the PMP is presented in the following sections. The development of the PMF and its impacts on the post-closure landforms and facilities is summarised later in this memorandum.

[3] "*The Estimation or Probable Precipitation in Australia: Generalised Short-Duration Method"* (BoM, 2003).
[4] *"Revision of the Generalised Tropical Storm Method for Estimating Probable Maximum Precipitation*", Hydrology Report Series No.8, Hydrometeorological Advisory Service (BoM, 2003).
[5] "*PMP and Other Extreme Storms: Concepts and Probabilities*" (Schaefer, M.G., 1994).

PMP Estimation

The selection of the PMP estimation methods is summarised on the PMP Method Selection Worksheet (refer to Attachment 1). This confirms the selection of the GSDM for annual events of up to six hour duration and the GTSMR Coastal Zone method for annual events of between 24 and 120 hour duration, as outlined below.

It should be noted that the GSDM has been applied to the Pilgangoora Creek catchment upstream of the proposed Central Pit/Pilgangoora Creek Diversion which will likely be required some 20 years after the start of mining and will remain post-closure. The catchment area upstream of this diversion was delineated previously and found to be approximately 6.350 km^2. The application of the GSDM to this smaller catchment area rather than the somewhat larger TMF Stage 2/Pilgangoora Creek Diversion catchment area (delineated previously as approximately 8.766 km^2) is considered to be conservative as the PMP rainfall depths provided by the method are higher for smaller catchments.

Generalised Short Duration Method (GSDM)

The GSDM was applied in accordance with the published BoM method and accompanying datasets (referenced above) and is summarised in the GSDM Calculation Sheet (refer to Attachment 2). The key steps were as follows:

- *Selection of Terrain Category* – the Pilgangoora Creek upstream catchment area was conservatively assumed to fall entirely within the "Rough" category i.e. elevation changes of 50 m or more within horizontal distances of 400 m are common.

- *Adjustment for Catchment Elevation* – an Elevation Adjustment Factor (EAF) of 1.0 was adopted as the approximate 200 mAHD mean elevation of the Pilgangoora Creek catchment is lower than 1500 mAHD elevation above which the EAF requires adjustment.

- *Adjustment for Moisture* – the catchment average extreme precipitable water (EPW) of 109.26 mm (calculated later as part of the GTSMR) was divided by the standard GSDM EPW of 104.5 mm to give a catchment average MAF of 1.0456.

- *Initial PMP Rainfall Depth Estimates* – values for "Rough" catchments with an area of 6.35 km^2 were read from the "Depth-Duration-Area Curves of Short Duration Rainfall" figure (refer to Attachment 3) to give initial rainfall depths for event durations of between 15 minutes (0.25 hours) and 6 hours.

The initial PMP rainfall depth estimates were then multiplied by the EAF and MAF and rounded to the nearest 10 mm to yield the PMP depths summarised in Table 1.

Table 1: GSDM PMP Rainfall Depth Estimates

Duration (hours)	PMP Depth (mm)	Duration (hours)	PMP Depth (mm)	Duration (hours)	PMP Depth (mm)	Duration (hours)	PMP Depth (mm)
0.25	230	1.0	500	2.5	830	5.0	1,140
0.50	340	1.5	650	3.0	900	6.0	1,240
0.75	430	2.0	750	4.0	1,040	-	-

Generalised Tropical Storm Method (GTSMR) - Coastal Zone

The GTSMR Coastal Zone method was applied for annual events in accordance with the published BoM method and accompanying datasets (referenced above) and is summarised in the GTSMR Calculation Sheet (refer to Attachment 4). The key steps were as follows:

- *Obtain Raw PMP Rainfall Depths* – were interpolated for the 6.35 km^2 Pilgangoora Creek upstream catchment area using the depth-area data for the Coastal-Annual dataset for event durations of between 24 and 120 hours.

- *Adjustment for Moisture* – The MAF is the ratio of the extreme precipitable water at the catchment site ($EPW_{catchment}$) to the standard extreme precipitable water ($EPW_{standard}$) which is 120.0 mm. The gridded EPW dataset was imported using GIS tools and an average $EPW_{catchment}$ value of 109.26 mm was obtained for the Pilgangoora Creek upstream catchment area, resulting in a MAF adjustment factor of 0.911.

- *Adjustment for Decay Amplitude* – the gridded decay amplitude factor (DAF) dataset was imported using GIS tools and a DAF factor of 1.0 was obtained (this value was constant over the entire project area).

- *Adjustment for Topography* – the gridded topographic adjustment factor (TAF) dataset was imported using GIS tools and a TAF factor of 1.0 was obtained (this value was constant over the entire project area).

- *Preliminary GTSMR PMP Rainfall Depths* – the raw depths for each standard duration were multiplied by the three catchment adjustment factors (i.e. PMP Estimate = Raw PMP depth × MAF × DAF × TAF) which were then rounded to the nearest 10 mm to yield the "Preliminary PMP Estimates" shown on the GTSMR calculation sheet. The GSDM values (estimated above) for event durations of between 1 and 6 hours were also added.

- *Final GTSMR PMP Rainfall Depths* – both the GSDM and GTSMR values were plotted and a curve was fitted to smooth out any discontinuities.

The resulting combined GSDM and GTSMR depth estimates are summarised in Table 2.

Table 2: Combined GSDM & GTSMR PMP Rainfall Depth Estimates

Duration (hours)	PMP Depth (mm)	Duration (hours)	PMP Depth (mm)
1	500	24	1,250
2	750	36	1,530
3	900	48	1,790
4	1,040	72	2,250
5	1,140	96	2,520
6	1,210	120	2,650
12	1,230	-	-

The resulting PMP depth estimates have been plotted along with the intensity-duration-frequency (IDF) and depth-duration-frequency (DDF) data developed previously for the project and shown in Figure 1 and 2 on the following pages.

Figure 1: PMP Rainfall Intensity Estimates and Pilgangoora Rainfall Intensity-Duration-Frequency Relationship

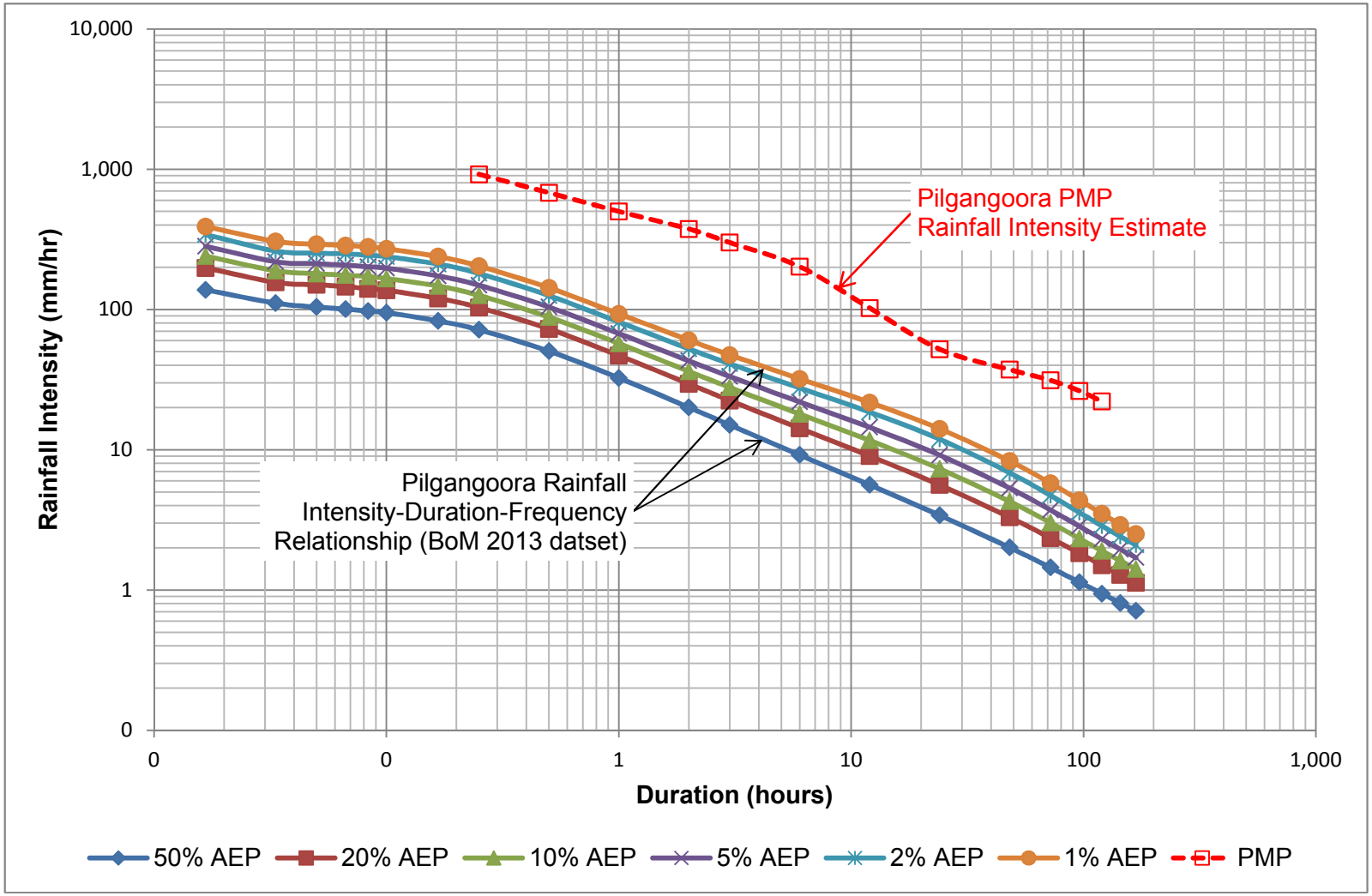
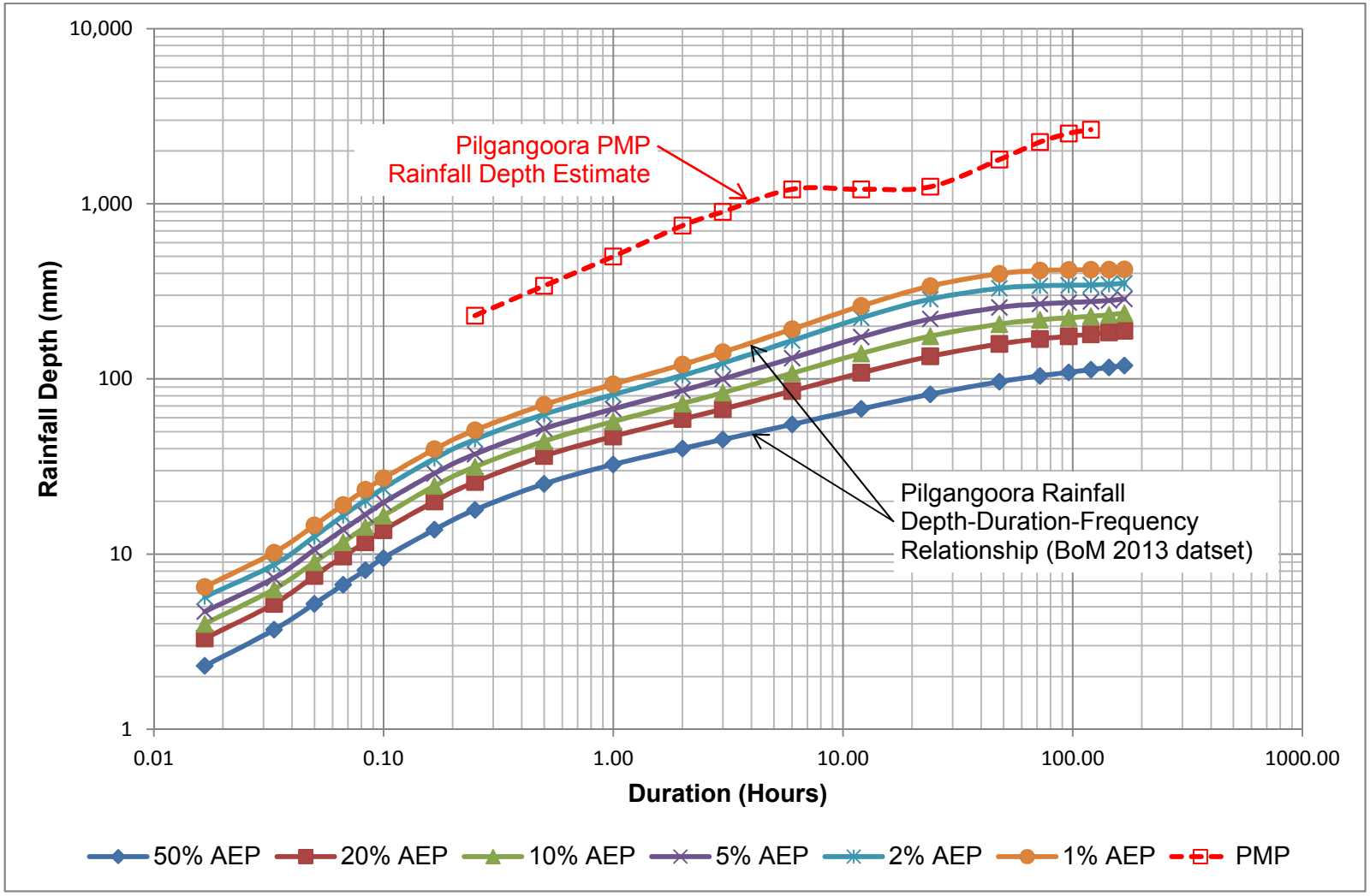


Figure 2: PMP Rainfall Depth Estimates and Pilgangoora Rainfall Depth-Duration-Frequency Relationship



Inspection of Figures 1 and 2 clearly demonstrates the extreme nature of the PMP event with rainfall intensities and depths, on average, over five times greater than the corresponding values for the 100 year ARI (i.e. 1% AEP) event.

PMP Spatial Distribution

Given the relatively small Pilgangoora Creek upstream catchment area (6.35 km^2) it has conservatively been assumed that there is no spatial distribution of the PMP and that, if it were to occur, it would be distributed uniformly across the catchment i.e. all parts would experience the same rainfall depth.

If a much larger catchment area (say >1,000 km^2) was being considered, then it would be prudent to make allowances for the spatial distribution as it is unlikely that all parts of the catchment would record the same rainfall depth.

PMP Temporal Distribution

In order to transform the PMP into PMF design flood events of various durations it is necessary to consider the temporal distribution of the rainfall during the storm as it is highly unlikely that it will occur with the same intensity throughout the entire storm. Both the GSDM and GTSMR methodologies include design temporal patterns that have been based on temporal patterns of observed significant storms. These design patterns have been adopted as necessary in the PMF estimation summarised below.

PMF Estimation

The transformation of the PMP to produce a PMF design flood event can be complex and requires significant hydrological modelling that is unlikely to be understood by non-specialists. Therefore for the purposes of the MCP it has been decided to adopt a simple but conservative approach based on the Rational Method. This assumes that the time of concentration is also the critical storm duration (i.e. the duration producing the highest discharge) and that there are no losses across the catchment (i.e. 100% runoff).

The ARR[6] equation for Pilbara catchment time of concentration (i.e. $t_c = 0.56 \times Area^{0.38}$) to the 6.35 km^2 Pilgangoora Creek upstream catchment area yields a 1.13 hour or 68 minute time of concentration. Therefore a PMP rainfall depth of 500 mm for an even more conservative 60 minute duration event (i.e. 500 mm/hr rainfall intensity) was adopted for the PMF. It should be noted that this is more than five times greater than the estimated 100 year ARI (1% AEP) 1 hour duration intensity of 93.2 mm/hr developed previously.

Submission of this design intensity provides peak PMF flow estimates in the order of 880 m^3/s and 1,220 m^3/s at the inlet to the proposed Central Pit/Pilgangoora Creek Diversion and TMF Stage 2/Pilgangoora Creek Diversion respectively. When compared to the commensurate peak flow rates of 164 m^3/s and 196 m^3/s obtained previously for the 100 year ARI (1% AEP) event, the significance of the PMF event is shown.

The impact of these PMF peak flows and the PMP rainfall depths on the post-closure landforms and facilities is discussed in the following sections.

[6] "*Australian Rainfall and Runoff*" (Institution of Engineers Australia, 1987).

PMP/PMF Post-Closure Impacts

Introduction

Clearly, given the magnitude of the PMP/PMF event, if it were to occur, it would not only impact the proposed Pilgangoora mining area but would also likely have a considerable effect on both natural (undisturbed) and modified (disturbed) catchments and infrastructure across the region. The immediate effects of the tropical depression related event(s) leading to the PMP/PMF would include exceptionally high/damaging winds, intense rainfall, concentrated runoff, flooding, erosion and sediment transport/deposition, storm surge, airborne debris, removal of foliage/tree canopy etc. The PMP/PMF would then likely be followed by a prolonged period of extraordinarily high flows and water levels along both local creeks (Northern, Houston, Pilgangoora and Southern Creeks) and regional rivers (Turner, Yule and Strelley Rivers). These flows would inundate floodplains causing road/rail/power/water infrastructure damage or loss, flooding of pastoral land, disruption of road/rail/air/sea transportation etc. Mining across the Pilbara region would be negatively impacted with many mines closed for extended periods and some perhaps failing to re-open[7].

The PMP/PMF effects at the proposed Pilgangoora mining area post-closure would be moderated to some extent by the fact that, as reported previously, the regional watershed divide is located about 2 km to the east of the site and the upstream catchment areas are relatively limited (<10 km^2 in all cases). In addition, the pits will be established within a range of north-south trending hills of up to about 80 m relief, with pit crests daylighting mostly at elevated locations. For these reasons and the fact that primary flood protection will be offered to the proposed pits by the construction of waste rock dumps along the eastern/upstream side of the proposed pits, the majority of the pit crests will have an inherently high level of flood protection.

Prior to closure the upper surfaces and side slopes of the various WRD's and the TMF will be fully rehabilitated and re-grading and drainage measures will be used to direct storm runoff in-pit as much as possible. Positive drainage by gravity will be used to ensure that standing water will not accumulate on any of the WRD or TMF final surfaces. Runoff will be directed off these landforms using appropriately designed water management structures incorporating rock linings, energy dissipators, adequate spacing/dimensions and minimal longitudinal gradients.

It is likely only where pit crests and other facilities are established in valleys between the existing hills that they are considered to be at a significant potential risk from flooding as a result of the PMP/PMF event. This is particularly the case for the southern crest of the proposed Central Pit and Stage 2 TMF embankment which will both intersect Pilgangoora Creek some 20 years after start-up and will require diversion channels to be constructed.

The PMP/PMF impacts on the pit voids and both of the proposed future Pilgangoora Creek diversions are quantified in the following sections.

[7] Following the passage of Tropical Cyclone Bobby across the Goldfields region in February 1995 many mining operations were severely flooded and failed to re-open, as reported in "*Report on a survey of the effects of Cyclone Bobby on Western Australian Mines*" (Chamber of Mines and Energy of Western Australia, Department of Minerals and Energy, Western Australia, 1996). This event was likely in the 200 to 300 year ARI (0.50% to 0.33% AEP) range and was significantly less than the regional PMP event.

In-Pit Water Levels following PMP/PMF

A highly conservative approach was adopted to quantify the likely runoff volume that will report to the Pilgangoora pit voids post-closure and the resulting increase in pit lake water level. The following "worst case" assumptions and factors were used:

- *Pit Lake Conditions Post-Closure* – the maximum pit lake levels and volumes assuming antecedent "high rainfall" conditions were adopted from GRM's pit lake closure modelling report (J160002L03b). The maximum pit lake levels under these conditions were found to be approximately 12 to 13 m higher than those for "base case" conditions. This previous work incorporates the elevation-area-storage relationships for each of the pit voids as provided to GRM by Mining Plus.

- *Pit Catchment Areas* – in-pit and ex-pit catchment areas from GRM's surface water management assessment report (J160002R02) were used. These assume that the maximum possible ex-pit areas will be diverted in-pit at the end of mining and ignores the additional flood protection provided by abandonment bunds, pit crest safety berms, remnant surface water diversions etc.

- *PMP/PMF Event* – the maximum 120 hour (5 day) duration PMP rainfall depth (2,650 mm) was assumed along with a 100% runoff coefficient i.e. zero losses.

The resulting runoff volumes, pit lake water level rise and remaining freeboard to each of the pit crests is summarised in Table 3 on the following page. Inspection of the results indicates that even allowing for all of the conservative assumptions and factors outlined above there is sufficient storage capacity within all of the pit voids to store the PMP/PMF event. The potential for loss of potentially poorer quality water stored in-pit off-site is therefore considered to be *highly unlikely*.

PMP/PMF Impacts on Proposed Future Pilgangoora Creek Diversions

The preliminary engineering design parameters of both the Central Pit/Pilgangoora Creek and Stage 2 TMF/Pilgangoora Creek diversions were presented previously in GRM's surface water management assessment report (J160002R02) and are summarised in Tables 4 and 5.

Table 4: Central Pit/Pilgangoora Creek Diversion Preliminary Design Parameters

Parameter	Unit	Value	Comment
100 year ARI (1% AEP) Design Flow	m^3/s	164	RFFE model for 6.350 km^2 catchment
Channel Length	m	650	Measured in AutoCAD
Inlet Invert Elevation	mRL	184.30	Based on survey pick-up
Outlet Invert Elevation	mRL	180.00	Based on survey pick-up
Minimum Channel Slope	m/m	0.0066	0.66 %
Manning's Roughness 'n'	-	0.045	Assumed jagged rock surface
Channel Base Width	m	25	Design value
Channel Sideslope Angle	-	26.6°	2H:1V
Channel Flow Depth	m	2.1	100 yr ARI (1% AEP) flow depth
Channel Freeboard (min.)	m	0.9	From Manning's equation
Channel Depth (min.)	m	3.0	Flow depth + Min. Freeboard
Channel Width (min.)	m	37	Width between shoulders

Table 3: Assessment of In-Pit Water Levels following PMP/PMF

Pit Name	Maximum Pit Lake Level[1] (mRL)	Maximum Pit Lake Volume[1] (m^3)	In-Pit Catchment[2] (m^2)	Ex-Pit Catchment[2] (m^2)	Total Catchment Reporting In-Pit[2] (m^2)	PMP/PMF Runoff Volume[3] (m^3)	In-pit Total Water Volume[4] (m^3)	Maximum PMP/PMF Lake Level[5] (mRL)	Lake Level Rise due to PMP/PMF[6] (m)	Remaining Freeboard[7] (m)
Monster Pit	156.9	1,790,438	190,000	613,250	803,250	2,128,613	3,919,050	180.9	24.0	18.1
Eastern Pit	144.7	10,036,272	404,775	1,420,742	1,825,517	4,837,620	14,873,892	163.9	19.2	22.1
Central Pit	88.0	11,755,935	661,750	891,500	1,553,250	4,116,113	15,872,048	102.1	14.1	78.9
Southern Pit	133.6	1,000,105	184,450	445,900	630,350	1,670,428	2,670,533	158.8	25.2	24.2
South End Pit	167.0	1,570,622	149,900	249,700	399,600	1,058,940	2,629,562	181.3	14.3	17.7

Notes:
1. Maximum pit lake levels and volumes assuming antecedent “high rainfall” conditions adopted from GRM’s pit lake closure modelling report (J160002L03b).
2. In-pit and ex-pit catchment areas from GRM’s surface water management assessment report (J160002R02).
3. Maximum 120 hour (5 day) duration PMP rainfall depth (2,650 mm) was adopted along with a 100% runoff coefficient i.e. assumes zero catchment losses.
4. Combined total of maximum starting pit lake volume + PMP/PMF runoff volume.
5. Interpolated from elevation-area-storage relationships for pit voids provided Mining Plus.
6. Maximum PMP/PMF Lake Level - Maximum Pit Lake Level.
7. Pit crest elevation - Maximum PMP/PMF Lake Level.

Table 5: TMF Stage 2/Pilgangoora Creek Diversion Preliminary Design Parameters

Parameter	Unit	Value	Comment
100 year ARI (1% AEP) Design Flow	m^3/s	196	RFFE model for 8.766 km^2 catchment
Channel Length	m	2,190	Measured in AutoCAD
Inlet Invert Elevation	mRL	175.0	Based on survey pick-up
Outlet Invert Elevation	mRL	169.0	Based on survey pick-up
Minimum Channel Slope	m/m	0.0027	0.27 %
Manning's Roughness 'n'	-	0.045	Assumed jagged rock surface
Channel Base Width	m	15	Design value
Channel Sideslope Angle	-	60°	0.58H:1V
Channel Flow Depth	m	4.5	100 yr ARI (1% AEP) flow depth
Channel Freeboard (min.)	m	0.5	From Manning's equation
Channel Depth (min.)	m	5.0	Flow depth + Min. Freeboard
Channel Width (min)	m	20.8	Width at shoulders

Both diversions have been conceptualised as in-ground (i.e. rock-cut) channels where the inlet/outlet elevations and longitudinal gradient were fixed by the existing Pilgangoora Creek channel invert and the channel base width was selected to convey the 100 year ARI (1% AEP) peak flow with a minimum of 0.5 m freeboard. Channel base widths of 25 m and 15 m and side slope angles of 26.6° and 58° were selected for the preliminary design of the Central Pit and TMF Stage 2 channel respectively resulting in *minimum* design depths (including freeboard) of 3.0 m and 5.0 m respectively.

In reality the depth of both diversions will likely be much deeper than these minimum design depths and may be up to approximately 5.5 m and 10.5 m deep at the deepest locations along the Central Pit and TMF Stage 2 channel respectively. As a result the maximum hydraulic capacity of both channels as currently designed is much greater than required for the 100 year ARI (1% AEP) peak flow. Manning's equation based calculations show that the maximum capacity of both diversion channels, including the freeboard allowance, is likely in the order of 750 m^3/s and 740 m^3/s for the Central Pit and TMF Stage 2 channel respectively at the deepest locations (refer to Attachment 5).

The PMF peak flow estimates of 880 m^3/s and 1,220 m^3/s developed earlier for the Central Pit/Pilgangoora Creek and TMF Stage 2/Pilgangoora Creek channel respectively are somewhat greater than the maximum hydraulic capacity of the diversions as currently designed. However a relatively modest increase in the base width and/or flattening of the channel side slope angle would result in sufficient hydraulic capacity to convey the PMF peak flow. Under PMF conditions the flow velocity will likely increase by some 50 to 60% over that for the 100 year ARI (1% AEP) event but, given that the bulk of both channels will be rock-cut (i.e. the channel inverts and sides will comprise fresh, hard country rock requiring drilling and blasting to construct) and that peak flow conditions will likely only last for a few hours, it is unlikely that significant damage will occur to either of the channels.

Given that neither diversion channel will be required until about 20 years after the start of mining their detailed design has not yet been undertaken. It is recommended that the preliminary design presented previously by GRM be modified slightly to take into account PMF conditions.

Conclusion

PMP and PMF estimates have been developed for the proposed Pilgangoora project site. These estimates show that PMP rainfall depths of approximately 500, 1,250 and 2,250 mm could occur over 1, 24 and 72 hour periods respectively and that peak PMF flows in the order of 880 m^3/s could be generated by the Pilgangoora Creek catchment upstream of the proposed Central Pit (commensurate values for the 100 year ARI (1% AEP) event are 93, 339 and 416 mm and 164 m^3/s).

An evaluation of the potential PMP/PMF impacts on the Pilgangoora project site post-closure would be moderated to some extent by the following:

- The regional watershed divide is located about 2 km to the east of the site and the upstream catchment areas are relatively limited (<10 km^2 in all cases).

- The proposed pits will be established within a range of north-south trending hills of up to about 80 m relief, with pit crests daylighting mostly at elevated locations well above nearby creeklines and drainages.

- Primary flood protection will be provided to the proposed pits by the construction of waste rock dumps along the eastern/upstream side of the proposed pits.

- Prior to closure the upper surfaces and side slopes of the various WRD's and the TMF will be fully rehabilitated and re-grading and drainage measures will be used to direct storm runoff in-pit as much as possible. Positive drainage by gravity will be used to ensure that standing water will not accumulate on any of the WRD or TMF final surfaces. Runoff will be directed off these landforms using appropriately designed water management structures incorporating rock linings, energy dissipators, adequate spacing/dimensions and minimal longitudinal gradients.

A "worst case" assessment of the in-pit storage capacity of the five proposed pit voids shows that there is sufficient storage capacity to store the PMP/PMF event and the potential for loss of potentially poorer quality in-pit water reporting off-site is considered to be *highly unlikely*.

It is likely only where pit crests and other facilities are established in valleys between the existing hills that they are considered to be at a significant potential risk from flooding as a result of the PMP/PMF event. This is particularly the case for the southern crest of the proposed Central Pit and Stage 2 TMF embankment which will both intersect Pilgangoora Creek some 20 years after start-up and will require diversion channels to be constructed.

A review of the preliminary design of these channels (presented previously by GRM) shows that a relatively modest increase in the base width and/or flattening of the channel side slope angle would result in sufficient hydraulic capacity to convey the PMF peak flow. Under PMF conditions the increased flow velocity is not considered to be problematic given that the bulk of both channels will be rock-cut (i.e. the channel inverts and sides will comprise fresh, hard country rock requiring drilling and blasting to construct) and that peak flow conditions will likely only last for a few hours.

Should you have any queries regarding the findings of this memorandum please do not hesitate to contact us.

Yours sincerely,





Alistair Lowry
Civil Engineering Hydrologist

Rob Garnham
Principal Hydrogeologist

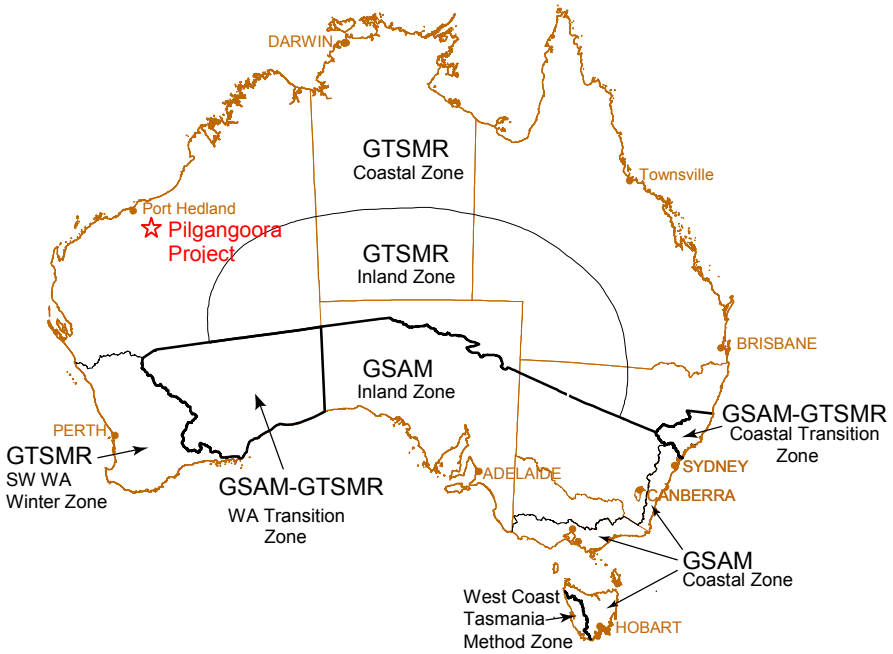
Attachments:

1. PMP Method Selection Worksheet
2. GSDM Calculation Sheet
3. GSDM Depth-Duration-Area Curves of Short Duration Rainfall
4. GTSMR Calculation Sheet
5. Hydraulic Capacity of Central Pit/Pilgangoora Creek and TMF Stage 2/Pilgangoora Creek Diversion Channels

ATTACHMENT No. 1 - PMP METHOD SELECTION WORKSHEET

Catchment Name: **Pilgangoora Creek (Upstream)** Upstream Catchment Area: **6.35 km^2**

LONG DURATION PMP



Note: Not to Scale – Project location approximate.

CIRCLE THE ZONE IN WHICH THE CATCHMENT IS LOCATED:

GTSMR (Coastal)

~~GTSMR (Inland)~~

~~GTSMR (Coastal & SWWA)~~

~~Coastal Transition - GTSMR Coastal - GSAM Coastal~~

~~GSAM (Coastal)~~

~~WA Transition - GTSMR Coastal - GSAM Inland~~

~~GSAM (Inland)~~

~~WCTas~~

SHORT DURATION PMP (GSDM)

Is the catchment less than 1000km²?

NO → Short duration PMP estimates can **not** be calculated for the catchment

YES

Is the catchment less than 500km² and south of 30°S?

NO → PMP estimates for up to 6 hours can be calculated using the **GSDM** for this catchment

YES → PMP estimates for up to 6 hours can be calculated using the **GSDM** for this catchment and can include **winter** estimates

PMP METHOD SUMMARY

Fill in the table below with the PMP method/s applicable to the catchment, referring to Table 1.1 for any additional information needed. NB: for the Transition zones, write separate entries for GTSMR and GSAM.

METHOD	ZONE	SEASON	DURATIONS
GSDM	6 hours	Annual	1-6 hours
GTSMR	Coastal	Annual	24-120 hours

WHAT NEXT?

GTSMR:	Calculate the PMP estimates for the catchment following the procedures in this guidebook
GSDM:	Calculate the PMP estimates for up to 6 hours following the GSDM (Bureau of Meteorology, 2003) guidebook (http://www.bom.gov.au/hydro/has/gsdm_document.shtml)
~~**GSAM:**~~	~~Contact the Hydrometeorological Advisory Service, Bureau of Meteorology~~
~~**WCTas:**~~	~~Contact the Hydrometeorological Advisory Service, Bureau of Meteorology~~

ATTACHMENT No. 2 - GSDM CALCULATION SHEET

LOCATION INFORMATION	
Catchment: **Pilgangoora Creek (Upstream)**	Area: **6.35 km^2**
State: **W.A.**	Duration Limit: **Six hours**
Latitude: **21.0583° S**	Longitude: **118.9083° E**
Portion of Area Considered:	
Smooth , **S** = **Nil** (0.0 - 1.0)	Rough , **R** = **1.0** (0.0 -1.0)

ELEVATION ADJUSTMENT FACTOR (EAF)

Mean Elevation: **200 m**

Adjustment for Elevation (-0.05 per 300 m above 1500 m): **Nil**

EAF = 1.0 (0.85 - 1.00)

GSDM MOISTURE ADJUSTMENT FACTOR (MAF)

$EPW_{catchment}$= 109.26

GSDM MAF=$EPW_{catchment}$/104.5

~~**OR**~~

~~read directly off GSDM Moisture Adjustment Factor chart~~

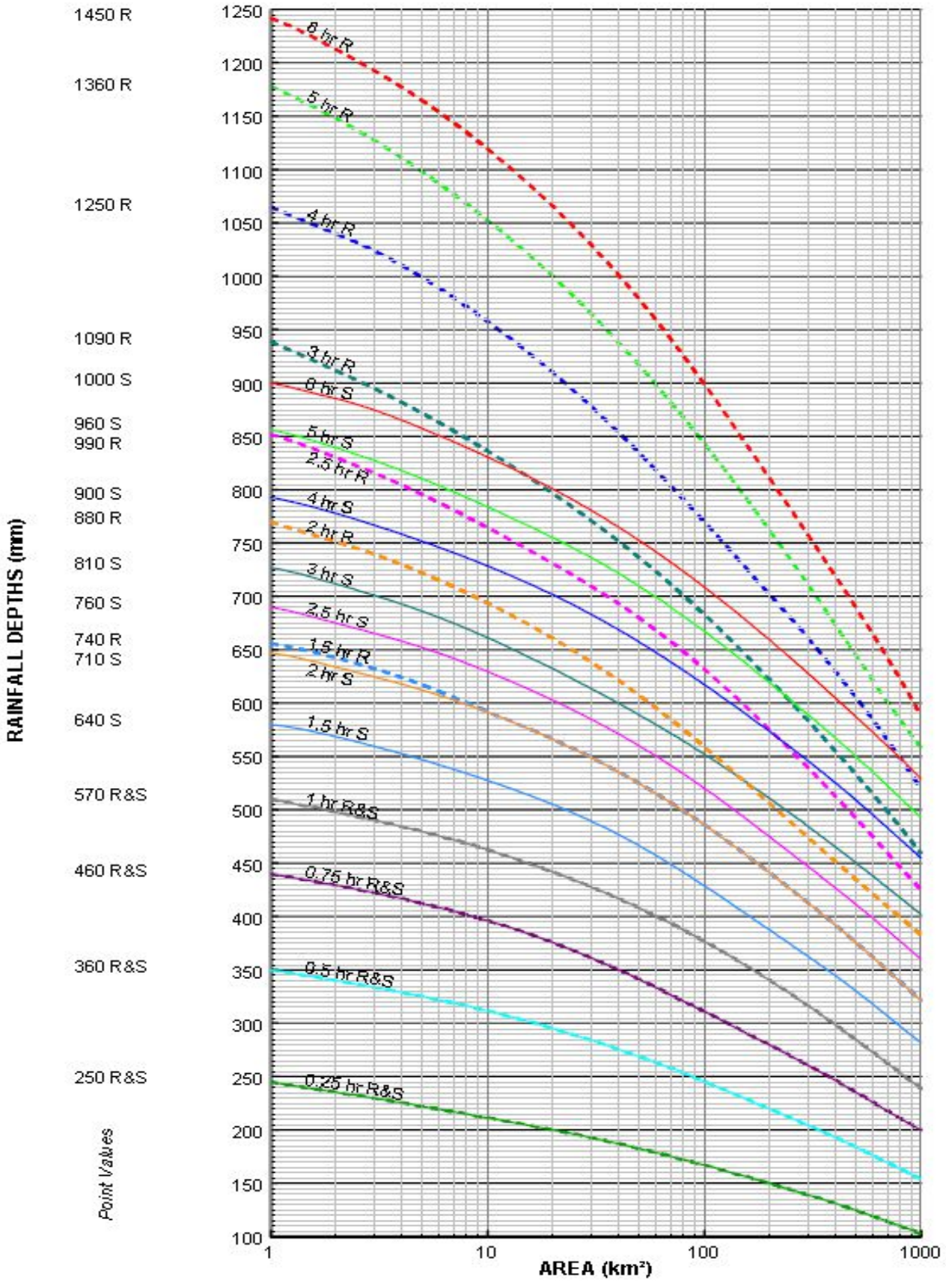
GSDM MAF = **1.0456** (0.46-1.19)

PMP VALUES (mm)

Duration (hours)	Initial Depth - Smooth (D_S)	Initial Depth - Rough (D_R)	PMP Estimate = (D_S×S + D_R×R) × MAF × EAF	Rounded PMP Estimate (nearest 10 mm)
.25	0	220	230.0	230
0.50	0	320	334.6	340
0.75	0	410	428.7	430
1.0	0	480	501.9	500
1.5	0	620	648.3	650
2.0	0	720	752.8	750
2.5	0	790	826.0	830
3.0	0	860	899.2	900
4.0	0	990	1,035.1	1,040
5.0	0	1,090	1,139.7	1,140
6.0	0	1,160	1,212.9	1,210

Prepared by: Alistair Lowry Date: 04 January 2017.

ATTACHMENT No. 3 - GSDM DEPTH-DURATION-AREA CURVES OF SHORT DURATION RAINFALL



ATTACHMENT No. 4: GTSMR CALCULATION WORKSHEET

LOCATION INFORMATION	
Catchment Name: **Pilgangoora Creek (Upstream)**	State: **W.A.**
GTSMR zone(s): **Coastal Zone**	

CATCHMENT FACTORS	
Topographical Adjustment Factor	**TAF** = 1.0 (1.0 – 2.0)
Decay Amplitude Factor	**DAF** = 1.0 (0.7 – 1.0)
Annual Moisture Adjustment Factor	$MAF_a = EPW_{catchment}/120.00$
Extreme Precipitable Water ($EPW_{catchment}$) = 109.26	**MAF_a** = 0.911 (0.4 - 1.1)
~~**Winter Moisture Adjustment Factor** (where applicable)~~	~~$MAF_w = EPW_{catchment_winter}/82.30$~~
~~Winter EPW ($EPW_{catchment_winter}$) = ……~~	~~**MAF_w** = …… (0.4 – 1.1)~~

PMP VALUES (mm) - Annual

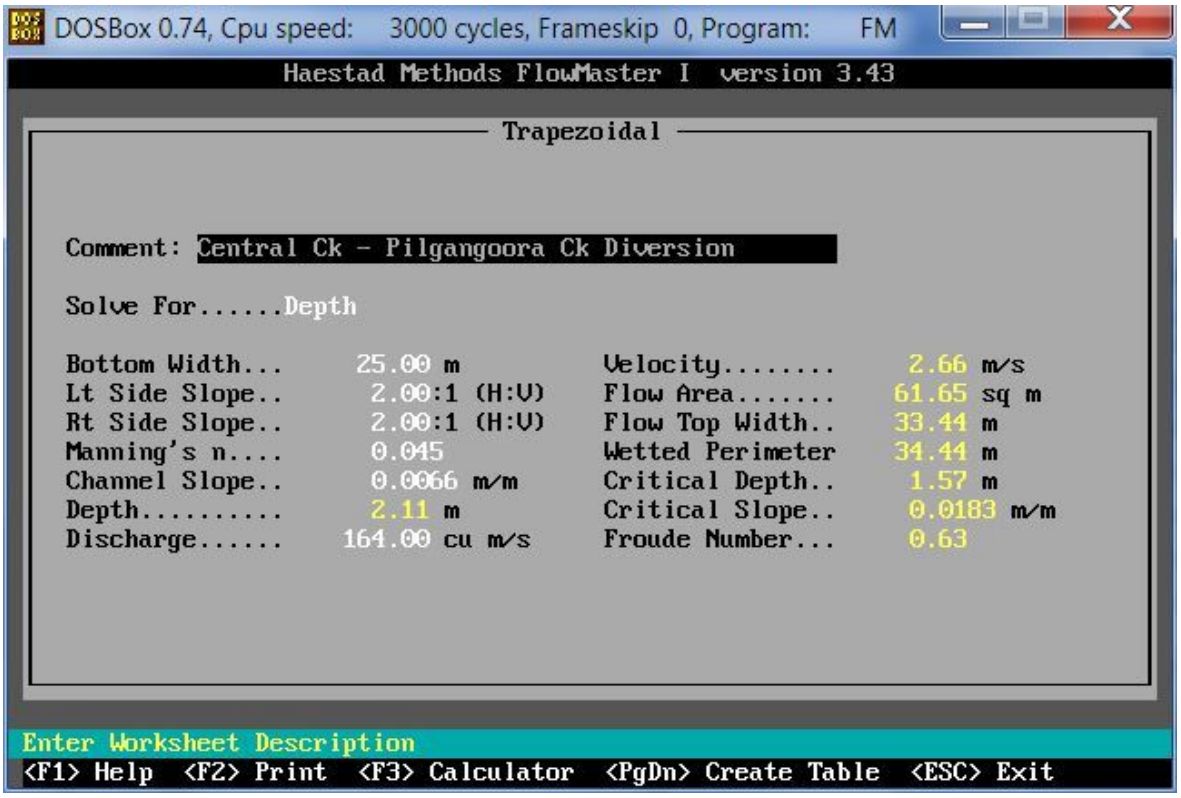
Duration (hours)	Initial Depth (D_a)	PMP Estimate $=D_a \times TAF \times DAF \times MAF_a$	Preliminary PMP Estimate (nearest 10mm)	Final PMP Estimate (from envelope)
1	Where applicable, calculate GSDM (Bureau of Meteorology, 2003) depths		500	500
2			750	750
3			900	900
4			1,040	1,040
5			1,140	1,140
6			1,210	1,210
12	(no preliminary estimates available)			1,230
24	1,368	1,246	1,250	1,250
36	1,678	1,528	1,530	1,530
48	1,965	1,789	1,790	1,790
72	2,474	2,253	2,250	2,250
96	2,770	2,522	2,520	2,520
120	2,912	2,651	2,650	2,650

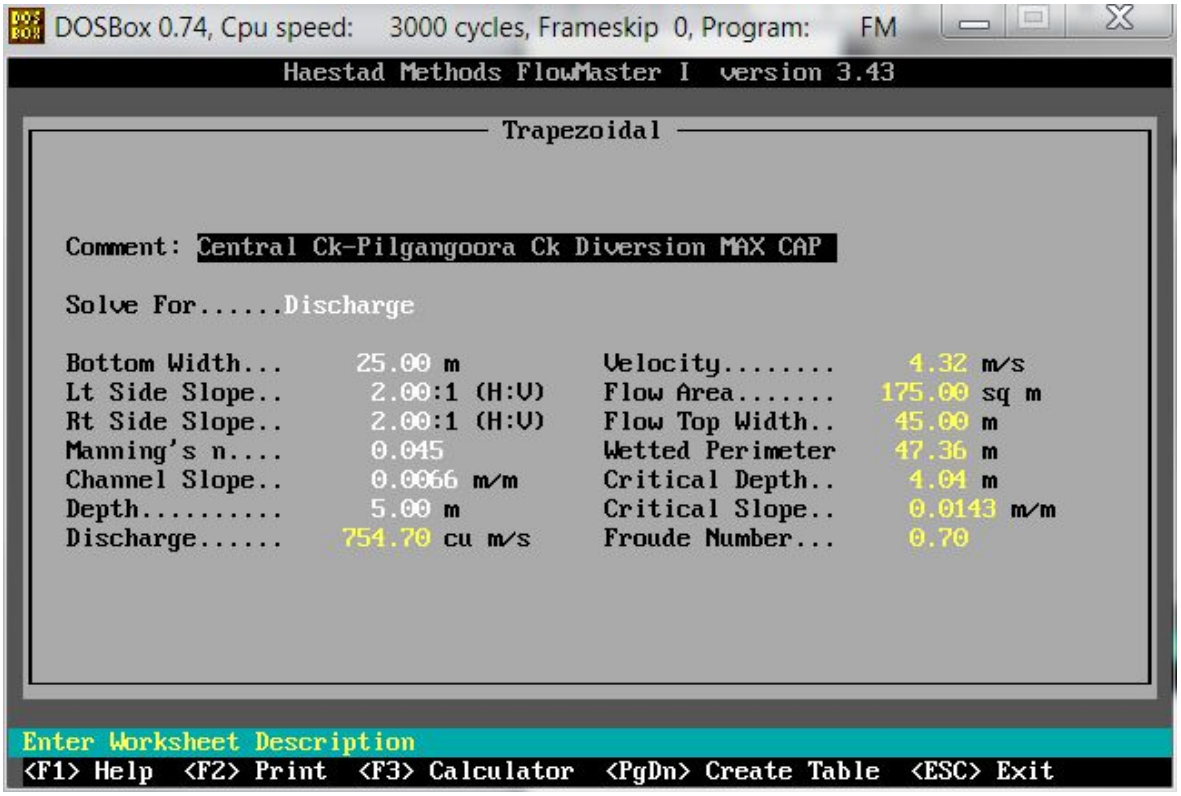
~~PMP VALUES (mm) – Winter~~ ~~(where applicable)~~

~~Duration (hours)~~	~~Initial Depth (D_w)~~	~~PMP Estimate $=D_w \times TAF \times DAF \times MAF_w$~~	~~Preliminary PMP Estimate (nearest 10mm)~~	~~Final PMP Estimate (from envelope)~~
~~1~~	~~Where applicable, calculate GSDM (Bureau of Meteorology, 2003) depths~~			N/A
~~2~~				N/A
~~3~~				N/A
~~4~~				N/A
~~5~~				N/A
~~6~~				N/A
~~12~~	~~(no preliminary estimates available)~~			N/A
~~24~~				N/A
~~36~~				N/A
~~48~~				N/A
~~72~~				N/A
~~96~~				N/A

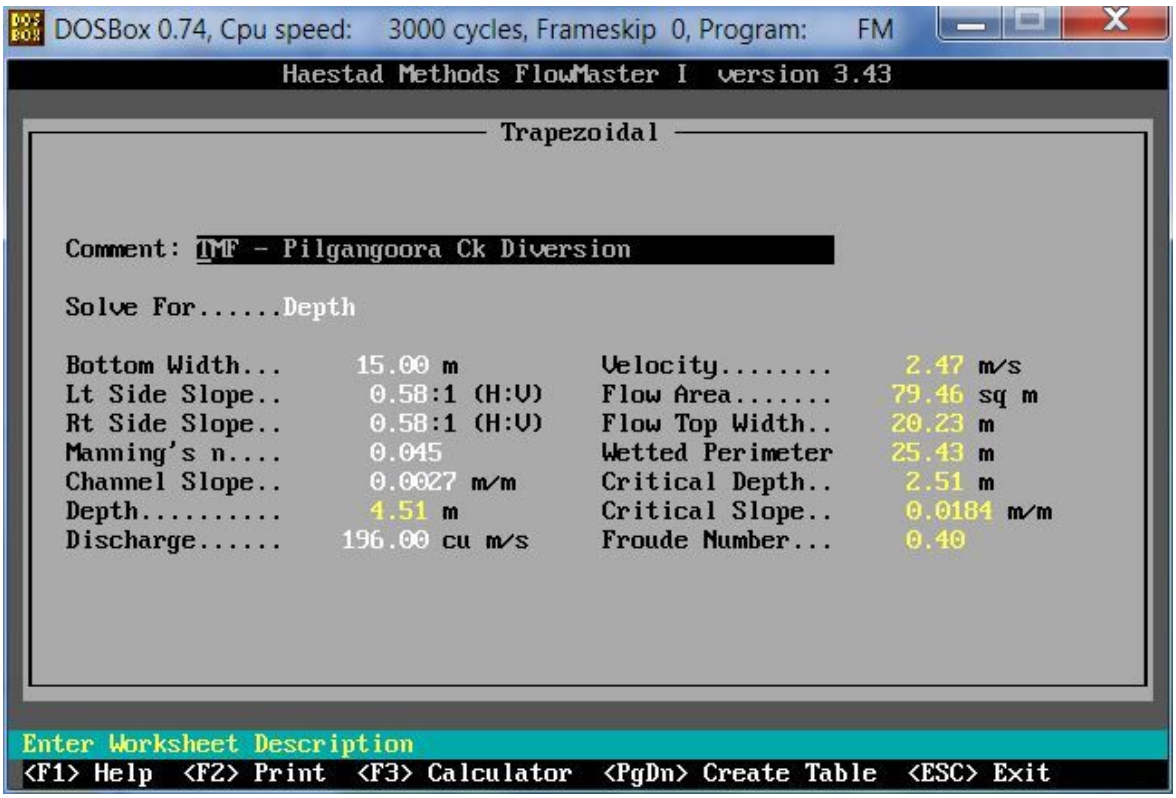
Prepared by: Alistair Lowry Date: 03/Jan/2017

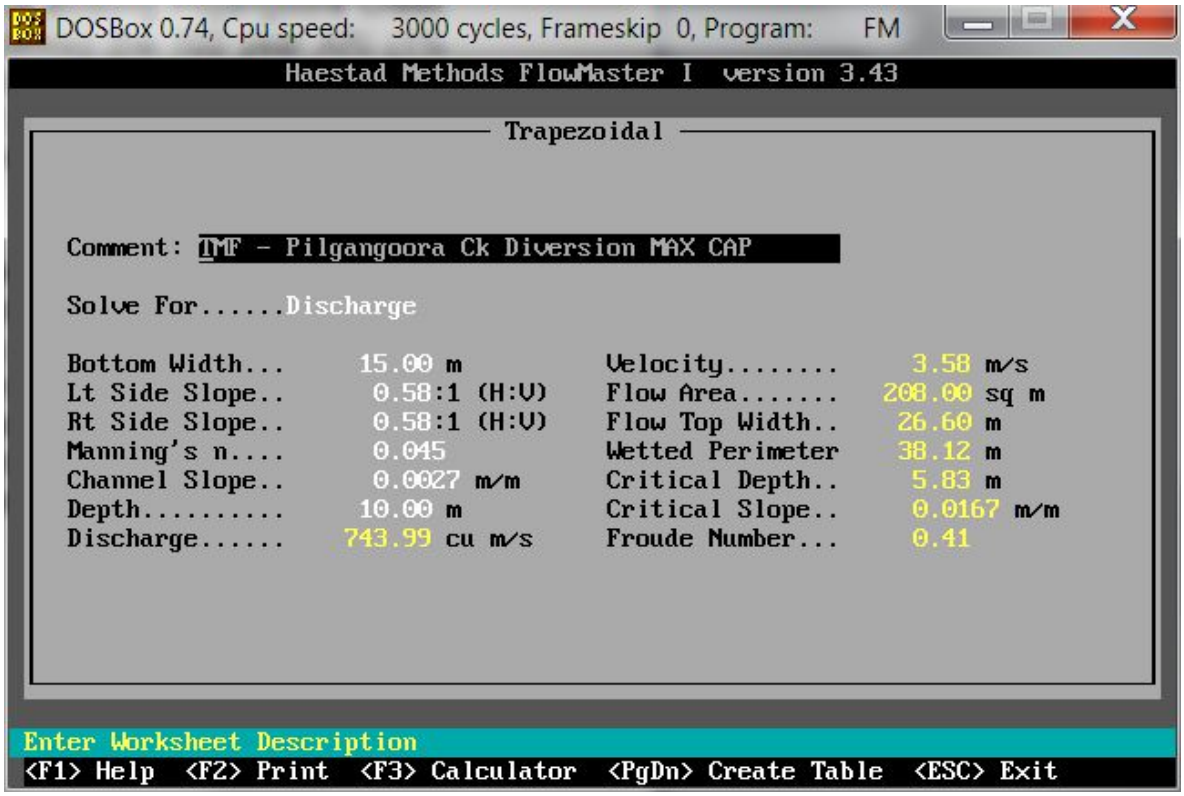
ATTACHMENT No. 5 - HYDRAULIC CAPACITY OF CENTRAL PIT/PILGANGOORA CREEK AND TMF STAGE 2/PILGANGOORA CREEK DIVERSION CHANNELS





ATTACHMENT No. 5 - Contd.





APPENDIX 2 – *ECOLOGIA* ENVIRONMENT SURVEY REPORT

ecologia Environment (2018) Altura Mining Ltd: Pilgangoora Lithium Project – M45/1260. Level 1 Fauna and Reconnaissance Flora and Vegetation Assessment

JULY 2018



Providing sustainable environmental strategies,
management and monitoring solutions
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ENVIRONMENT

ALTURA MINING LIMITED

PILGANGOORA LITHIUM PROJECT – MINING LEASE M45/1260

LEVEL 1 FAUNA AND RECONNAISANCE FLORA AND VEGETATION ASSESSMENT

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ACRONYMS

BAM Act	*Biosecurity and Agriculture Management Act 2007*
BOM	Bureau of Meteorology
BIF	Banded Ironstone Formation
CALM	Department of Conservation and Land Management (now DBCA and DER)
CAMBA	China – Australia Migratory Bird Agreement
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFWA	Department of Agriculture and Food Western Australia
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation (now DBCA)
DER	Department of Environmental Regulation
DoEE	Department of the Environment and Energy (Previously DSEWPaC)
DPaW	Department of Parks and Wildlife (now DBCA)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DoEE)
EPA	Environment Protection Authority
EP Act	*Environment Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESCAVI	Executive Steering Committee for Australian Vegetation Information
IA	International Agreement
IBRA	Interim Biogeographic Regionalisation for Australia
ICE	Incidence-based Coverage Estimators
IPA	Indigenous Protected Area
IUCN	International Union for Conservation of Nature
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
TEC	Threatened Ecological Community
TPFL	Threatened and Priority Flora database
TP List	Threatened and Priority Flora List
WA	Western Australia
WAHERB	Western Australian Herbarium Specimen Database
WAOL	Western Australian Organism List
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance

EXECUTIVE SUMMARY

ecologia Environment was commissioned by Altura Mining Limited to conduct a reconnaissance flora and vegetation survey and a Level 1 fauna survey to support approvals for the future development of mining lease M45/1260, immediately adjacent to the existing Altura Pilgangoora Lithium Project. The M45/1260 study area (the study area) comprises a vegetated area of approximately 345 ha located approximately 90 km south of Port Hedland (Figure 1.1).

Flora and vegetation assessment

A reconnaissance flora and vegetation survey was conducted from May 14th to 16th 2018. A total of 122 sub-generic vascular plant taxa from 71 genera and 27 families were recorded within the study area. Of these, two were State listed Priority Flora species (*Euphorbia clementii* and *Triodia chichesterensis*) and three were introduced (*Cenchrus ciliaris*, *C. setiger*, and *Echinochloa colona*).

Euphorbia clementii (Priority 3) was recorded from 27 locations (approx. 250 individuals) within the study area, where it was found almost exclusively on vehicle tracks and windrows. *Triodia chichesterensis* (Priority 3) was recorded from the eastern border of the study area where it formed a dominant component of the vegetation community present on stony quartzite plains. Based on current DBCA records, both species are well represented outside of the study area.

Two of the introduced species recorded (*C. ciliaris* and *C. setiger*) were primarily associated with a minor creek line and adjacent floodplains while *E. colona* was recorded in low abundance from small claypans (gilgai). These species are listed as 'Permitted' on the Western Australian Organism List (DAFWA 2016) and are not Weeds of National Significance.

Six vegetation units were described and mapped within the study area. None of these correspond to any TEC or PEC; however, one may be considered locally significant as it supports the Priority 3 species *Triodia chichesterensis*. Another unit supports *Eucalyptus victrix*, which is a facultative phreatophyte, that is, it is potentially groundwater dependant in situations where surface water is unavailable. Both units are expected to occur outside of the study area.

Vegetation condition across most of the study area was assessed as 'Very Good' to 'Excellent', with no or minimal weed invasion and insignificant grazing. Vegetation within the creek line and surrounding floodplain was rated as 'Good' due to more significant grazing and trampling by cattle and higher abundance of introduced species.

Fauna assessment

A Level 1 terrestrial vertebrate fauna and fauna habitat assessment of the study area was conducted concurrently with the reconnaissance flora and vegetation survey between May 14th to 16th 2018. The landscape of the study area is typical of the Satirist land system of the Pilbara Bioregion, and the area was associated with two broad fauna habitats: Stony Plains and Minor Drainage Lines. Most of the habitat present encompasses stony plains, with two minor drainage lines accounting for approximately 18 ha (5.5%) transecting the study area in an east west direction. Most of the habitat was in Very Good or Excellent condition with only one area classified as Poor due to extensive grazing and the presence of weeds. In the landscape context all of the identified habitat types are considered to be well represented elsewhere in the Bioregion, including within conservation reserves, and the study area is not considered to provide habitat important to the life history of any significant species. None of the habitats present are considered to be of national, state or regional significance. From a local perspective, drainage lines generally support greater species richness and abundance compared to other habitats and provide routes for immigration and emigration.

A total of 33 terrestrial vertebrate species were recorded during the survey including 27 birds, three mammals (two introduced) and three reptiles. One disused mound of the Western Pebble-mound Mouse (Priority 4) was also recorded.

Three listed species of conservation significance are likely to visit or forage within the study area. No suitable caves or roosting sites for the Pilbara Leaf-nosed Bat or Ghost Bat were found to occur; however, the Pilbara Leaf-nosed Bat may forage and disperse along Minor Drainage Line habitat from a known roost (the East Turner River Roost) northeast of the study area. The Western Pebble-mound Mouse is likely to occur in the Stony Plains habitats that provide pebbles of a suitable size for the construction of mounds, and the Rainbow Bee-eater would occur in all habitats over the study area and may utilise banks along drainage line habitat for breeding.

No denning habitat was present, and no other secondary evidence for the Northern Quoll (i.e. scats or tracks) was detected. As the closest Northern Quoll record is from approximately 16 km away, no suitable foraging habitat was assessed as being present, and as previous targeted surveys over adjacent tenements found no evidence of the species, it is considered unlikely to occur within the study area.

Stony Plains habitats within the study area are unlikely to support the burrowing species Greater Bilby and Brush-tailed Mulgara with few local records identified and a lack of suitable burrowing substrate and subsequent predation by feral predators likely to restrict the presence of other critical weight-range species such as the Spectacled Hare-wallaby.

The study area lacks suitable nesting habitat for the Peregrine Falcon; however, due to its wide-ranging habit and dietary preferences it may utilise all habitats of the study area as a part of a larger foraging area. The widespread Grey Falcon and Fork-tailed Swift may occasionally overfly the area without utilising any habitat present.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

Altura Mining Limited (Altura) required reconnaissance flora, vegetation and fauna surveys to support future environmental approvals for mining lease M45/1260, immediately adjacent to the existing Pilgangoora Lithium Project, located approximately 90 km south of Port Hedland (Figure 1.1).

The M45/1260 study area comprises a vegetated area of approximately 345 ha, immediately adjacent to the existing Altura Pilgangoora Lithium Project (Figure 1.1). *ecologia* Environment (*ecologia*) was commissioned by Altura to undertake a reconnaissance flora and vegetation survey and a Level 1 fauna and fauna habitat assessment of the study area.

1.2 SURVEY OBJECTIVES

The EPA's environmental objective for the factors *Flora and Vegetation* (EPA 2016a) and *Terrestrial Fauna* (EPA 2016b) is: "To protect flora and vegetation and terrestrial fauna so that biological diversity and ecological integrity are maintained." In the context, 'ecological integrity' is the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements. The primary objective of this flora and fauna assessment was to provide information for the EPA to assess the potential impact of the proposed development on the flora, vegetation and fauna of the study area, thereby ensuring that the EPA objectives will be upheld.

Reconnaissance (Level 1) surveys are undertaken to describe the broad environmental values of the study area, including flora and fauna assemblages, broad vegetation units and habitat types, and vegetation condition. The results of a reconnaissance survey may identify the need for a more detailed survey of the study area if significant flora, fauna, or vegetation are considered likely to be present. To this end, the following were provided as part of this assessment:

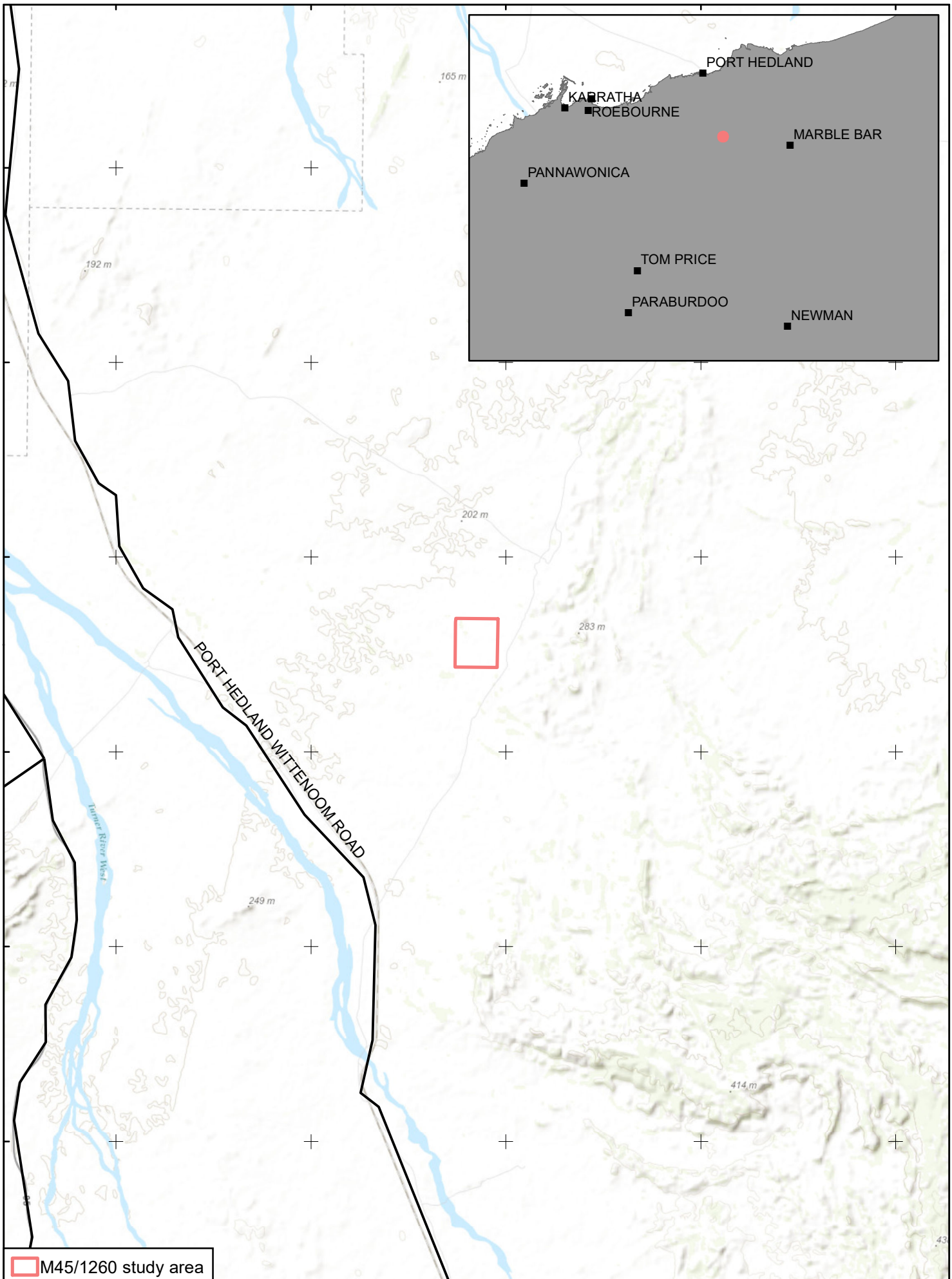
- A desktop study to evaluate biological values of the study area and surrounds, including a review of existing environmental values, threatened and priority flora, vegetation, and fauna databases, and other relevant available literature;
- A reconnaissance flora and vegetation survey to describe the broad environmental values of the study area;
- A targeted conservation significant flora survey;
- A Level 1 fauna survey incorporating background research and a reconnaissance survey to verify the accuracy of the background study, and to further delineate and characterise the faunal assemblage;
- An inventory of the flora and fauna of the study area;
- An inventory and a map of conservation significant species within the study area, and the local and regional distribution of these species where data are available;
- An inventory and a map of Declared Organisms within the study area;
- Description and mapping of vegetation units within in the study area;
- Assessment and mapping of the vegetation condition within the study area;
- Description and mapping of fauna habitats within the study area; and
- A detailed report summarising the findings of the field survey.

1.3 LEGISLATIVE FRAMEWORK

The surveys were designed and undertaken to comply with the following guidance documents:

- Environmental Factor Guideline: Flora and Vegetation (EPA 2016a);
- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016b);

- Technical Guidance– Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016c);
- Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016d); and
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016e).



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Drawn: AC Project ID: 1739
Date: 4 April 2018 A4

0 2 4
Kilometers
Scale: 1:200,000
MGA94 (Zone 50)

Location of M45/1260 study area

Figure: 1.1

2 DEFINITIONS

2.1 SIGNIFICANT FLORA

According to the *EPA Factor Guideline: Flora and Vegetation* (EPA 2016a), plant species (or records) may be considered significant for a number of reasons including, but not restricted to, the following:

- Being identified as Threatened or Priority species;
- Locally endemic species or those associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or those having anomalous features that indicate a potential new species;
- Being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; and
- Being representative of taxonomic groups that no longer occur widely in the broader landscape (relictual species/populations).

***Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia)**

At a Commonwealth level, Threatened Flora are protected under the EPBC Act, which lists species that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependant, Extinct, or Extinct in the Wild (refer to Appendix A for category definitions).

***Wildlife Conservation Act 1950* (Western Australia)**

At State level, Threatened Flora species are protected under the WC Act. These are taxa which have been adequately surveyed and are deemed to be either rare, in danger of extinction, or otherwise in need of special protection in the wild and are gazetted as Threatened (Declared Rare) Flora. Threatened Flora are further categorised by DPaW according to their level of threat using the International Union for Conservation of Nature (IUCN) red list criteria (IUCN 2001) (Appendix A). These taxa are legally protected and their removal or impact to their surroundings cannot be conducted without Ministerial approval, obtained specifically on each occasion for each population.

Priority Flora (DPaW)

DPaW maintains a list of Priority Flora species, which are considered poorly known, uncommon or under threat but for which there is insufficient justification to be listed as Threatened, based on known distribution and population sizes. Priority Flora species are assigned to one of four categories, described in Appendix A.

2.2 SIGNIFICANT VEGETATION

According to *EPA Factor Guideline: Flora and Vegetation* (EPA 2016a), vegetation may be considered significant for a number of reasons including, but not restricted to, the following:

- Being identified as Threatened or Priority Ecological Communities;
- Having a restricted distribution;
- The degree of historical impact from threatening processes;
- Playing a role as a refuge;
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

Threatened Ecological Communities (Nationally Listed)

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (DEC 2010). At a national level, Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of three sub-categories: Critically Endangered, Endangered, and Vulnerable (Appendix A).

Threatened Ecological Communities (State Listed)

DPaW maintains a list of state listed TECs which are further categorised into three subcategories, reflecting those of the EPBC Act. Within the Western Australian classification, an ecological community will be listed as Vulnerable "when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future".

Priority Ecological Communities

DPaW maintains a list of Priority Ecological Communities (PEC). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined. DPaW categorises PECs into five categories, P1 to P5, depending on the level of threat to the community (Appendix A).

Regional and Local Significance

Regional significance addresses the representation of habitats at a biogeographic regional level. Vegetation communities that are restricted or uncommon in a regional context are considered regionally significant. Vegetation communities supporting Threatened Flora species may also be considered regionally significant. Accurate assessment of regional significance requires sufficient regional vegetation community data to be available, and described at a similar level to the current study.

Locally significant vegetation may include vegetation communities that are locally restricted, contain comparatively high structural or species diversity, or contain Priority Flora species that are restricted to these vegetation communities.

2.3 INTRODUCED FLORA

Weeds of National Significance (WONS)

At a national level, there are 32 weed species listed as Weeds of National Significance (WONS). The Commonwealth National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance (DSEWPaC 2012b) describes broad goals and objectives to manage these species.

Declared Pests

The purpose of the *Biosecurity and Agriculture Management Act 2007* (BAM Act) is to prevent serious animal and plant pests and diseases from entering WA and becoming established, and to minimise the spread and impact of those that are already present. The BAM Act (and associated regulations) replaces the *Agriculture and Related Resources Protection Act 1976* (and associated regulations).

The BAM regulations were enacted on 1 May 2013, placing organisms into one of five legal status categories: Declared Pest - Prohibited, Declared Pest, Permitted, Permitted – Requires Permit, and Unlisted (Appendix A). The Western Australian Organism List (WAOL) (DAFWA 2016) lists organisms in each of these categories. Unlisted organisms must not be imported (unless in accordance with an import permit and regulations). The BAM Act further categorises Declared Pests in one of three control categories: C1 Exclusion, C2 Eradication, and C3 Management (Appendix A).

Environmental Weeds

A second and much more extensive categorisation of weeds has been developed by the Department of Parks and Wildlife (DPaW) (previously the Department of Environment and Conservation) in the State Environmental Weed Strategy (Department of Conservation and Land Management (CALM) 1999) . Weeds listed as Environmental Weeds are ranked into four control categories; Low (L), Mild (ML), Moderate (MD) or High (H). These are described in Appendix A.

2.4 SIGNIFICANT TERRESTRIAL FAUNA

According to *EPA Factor Guideline: Terrestrial Fauna* (EPA 2016b), terrestrial fauna may be considered significant for a number of reasons including, but not restricted to, the following:

- Being identified as a Threatened or Priority species (Appendix A);
- Species with restricted distribution;
- Degree of historical impact from threatening processes; and
- Providing an important function required to maintain the ecological integrity of a significant ecosystem.

Additionally, as described in EPA Guidance (EPA 2016e) terrestrial fauna may be considered significant for the following reasons:

- Species is protected by international agreement or treaty (i.e. migratory fauna);
- Species is a short-range endemic;
- Species has declining populations or distribution;
- Species is at the extreme of its range, or is part of an outlying population; and
- Species is undescribed.

Fauna habitats may be significant if they provide habitat important to the life history of a significant species, i.e. breeding, feeding and roosting or aggregation areas, or where they are unique or isolated habitats, for example wetlands, in the landscape or region (EPA 2016b).

***Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia)**

At the Commonwealth level, Threatened Fauna are protected under under Section 178 of the EPBC Act, which may list species as: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and conservation dependent. In addition, under sections 209 and 248 of the Act, some migratory and marine species are protected under international agreements.

***Wildlife Conservation Act 1950* (Western Australia)**

At the State level, some animal species are protected under the WC Act. 'Specially Protected Fauna' species are those which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such. Threatened Fauna are categorised by DPaW according to their level of threat using the IUCN red list criteria (IUCN 2001) and are a subset of Specially Protected Fauna declared to be 'likely to become extinct' pursuant to section 14(4) of the WC Act, and listed under Schedules 1 to 4. That is, critically endangered, endangered, vulnerable or presumed extinct. Specially Protected Fauna may also be listed as migratory, conservation dependent, or in need of special protection. (Note that the *Biodiversity Conservation Bill 2015* was introduced to State Parliament on 25th November 2015 and will eventually fully replace the WC Act.)

Priority Fauna (DBCA)

DBCA maintains a list of Priority Fauna species, which are considered poorly known, rare, near threatened or in need of monitoring but for which there is insufficient justification to be listed as

Threatened, based on known distribution and population sizes. Priority Fauna species are assigned to one of the four categories (Priority 1 to Priority 4) described in Appendix A.

Short-range Endemic Invertebrates (SREs)

EPA Guidance (EPA 2009) defines short-range endemics (SREs) as terrestrial and freshwater invertebrates that have naturally small distributions of less than 10,000 km^2, after Harvey (2002). The Western Australian Museum uses a three-tier classification scheme for SRE Taxa:

- **Confirmed SREs:** Species with a known range smaller than 10,000 km^2. Taxonomy is well known, and the group is well represented in collections and/or has been comprehensively sampled.
- **Potential SREs:** Species that belong to a group where there are gaps in our knowledge of the taxon, either because the group is not well represented in collections, taxonomic knowledge is incomplete, or the distribution is imperfectly understood because sampling has been patchy.
- **Widespread (not SREs):** Species that have a known distribution range larger than 10,000 km^2. The taxonomy is well known and the group is well represented in collections and/or has been comprehensively sampled.

3 METHODOLOGY

3.1 DESKTOP STUDY

Existing Environment

A desktop review of background environmental information relevant to the study area was undertaken by *ecologia* including data collected from previous flora, vegetation, and fauna surveys, climate (BoM), biogeography (IBRA 7) (USE 2012), land systems (Van Vreeswyk *et al.* 2004a), and pre-European vegetation (Shepherd *et al.* 2001).

Conservation Significant Flora, Fauna, and Ecological Communities

Searches of the following databases were undertaken in March 2017 (using the specified search buffers given below) to determine conservation significant species and communities recorded near the study area:

- Department of Environment (DoE) EPBC Act Protected Matters Database (50 km buffer);
- DBCA Threatened and Priority Flora List (TPFL) (Search reference 16-0418FL) (20 km buffer);
- Western Australian Herbarium Specimen Database (WAHERB) (Search reference 16-0418FL) (20 km buffer);
- DPaW Threatened and Priority Ecological Communities Database (Search reference 12-0317EC) (20 km buffer);
- DBCA NatureMap database (WA) (40 km buffer);
- DBCA Threatened and Priority Fauna database (WA) (25 km buffer) (Search reference 2018/000514 #5699);
- BirdLife Australia Custom Atlas Bird List (national) (50 km buffer).

Each conservation significant species and ecological community identified during the desktop study was assigned a likelihood of occurrence rating within the study area based on criteria shown in Table 3.1. The level of available information for each species or community was also taken into consideration so that species are not allocated a low rating because of insufficient survey information or cryptic behaviours and ecology.

Table 3.1 – Criteria used to assess likelihood of occurrence of significant flora and fauna

Rating	Criteria (significant flora and fauna)	Criteria (TEC/PEC)
Recorded	The taxon has been recorded within the study area.	The TEC/PEC (not including buffer) has previously been recorded in the study area.
Possible (1)	Suitable habitat is likely to occur within the study area, and there are previous records near the study area.	Due to the proximity of previous records and the likely presence of suitable habitat/geology within the study area, the TEC/PEC possibly occurs within the study area.
Possible (2)	Suitable habitat possibly occurs within the study area, but there are no records near the study area; or there is otherwise insufficient information available to exclude the possibility of occurrence.	The community is broadly defined and could possibly occur at the study area and there are records in the vicinity of the study area; or there is insufficient information available to exclude the possibility of occurrence at the study area.
Unlikely (3)	Suitable habitat is considered unlikely to be present within the study area.	The community is well defined and suitable habitat/geology is considered unlikely to be present within the study area.

3.2 FLORA AND VEGETATION

3.2.1 Field Methodology

A reconnaissance flora and vegetation survey was conducted at the M45/1260 study area from May 14th to 16th 2018. Survey methodologies adopted for the survey were in accordance with the *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016c). The survey was conducted by describing vegetation units at several sampling points, supplemented by a series of traverses along which changes in vegetation unit and disturbance were periodically noted. To provide a more detailed inventory of plants species for the study area, all species encountered during the survey were recorded.

Vegetation description sites

Vegetation communities were described from 28 low-intensity sampling sites within the study area. Site locations were selected using a combination of aerial photography, topographic features, landforms, and field observations to represent the diversity of vegetation present within the study area. At each site, the following data were recorded:

- Site number and location;
- Photograph of the vegetation community;
- Dominant growth form, height, cover and up to three species for the three traditional strata (upper, mid and ground) compatible with NVIS Level V (ESCAVI 2003);
- Additional information to assist vegetation description, including landform, soils, slope, aspect, rock type and abundance, litter, and fire history; and
- Vegetation condition (**Error! Reference source not found.**) and description of disturbance.

Site and dominant species data for each site is presented in Appendix J.

Threatened and Priority Flora species

Threatened and Priority Flora listed species identified from the database searches were targeted during the field survey, using previously recorded locations as well as known habitat preferences. The survey involved searches of potential suitable habitat and opportunistic records taken during traverses walked across the study area. Where conservation significant species were observed the following data were recorded:

- Recorder and date;
- Individual GPS coordinates (GDA94) (for individual or localised plants), or GPS coordinates of population extent (for more extensive populations);
- Number of plants (count, for individual or localised plants) or estimated number of plants via area calculation;
- Reproductive state;
- Vegetation type; and
- Landform.

Specimen identification

Specimen identification was undertaken with reference to current taxonomic literature and herbarium reference specimens. Scientific names used in this report follow species concepts currently adopted by the Western Australian Herbarium. Specimens that were believed to differ significantly from typical materal were indicated with 'affinity' (aff.). Specimens that could not be adequately identified to genus or species level due to the absence of flowering or fruit material required for positive identification were indicated with a question mark, but were not considered to be otherwise anomolous.

Vegetation mapping

Data collected from sampling sites, in addition to other field observations, were consolidated to decribe and map vegetation units within the study area. Vegetation units were described and mapped based on the dominant species present in the three traditional strata (if present), consistent with NVIS Level V. Extrapolative vegetation mapping based on aerial imagery and ground-truth data was used to map the described vegetation units within study area. Mosaic units were mapped in cases where two or more vegetation units occurred in a pattern too detailed to map separately at the mapping scale being applied.

3.2.2 Vegetation Condition Assessment

Vegetation condition was based on the scale as described in the Technical Guidance for the Flora and Vegetation Surveys for Environmental Impact Assessment for the Eremaean and Northern Botanical Provinces (EPA 2016c) (**Error! Reference source not found.**). Vegetation condition was mapped across the study area based on vegetation condition ratings recorded at sampling sites, as well as additional observations made during the survey.

3.2.3 Assessment of Vegetation Significance

Any significant vegetation communities recorded at the study area were assessed, where relevant regional data were available, for National, State, regional and local significance, using the definitions described in Section 2 above.

Table 3.2 – Vegetation condition scale

Vegetation Condition	Criterion
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

3.3 FAUNA

The survey methods adopted by *ecologia* for the survey accorded with the Technical Guidance for Sampling Methods for Terrestrial Vertebrate Fauna for a Level 1 fauna and fauna habitat assessment (EPA 2016d). Low-intensity fauna sampling was undertaken to detect vertebrate fauna of conservation significance both within and outside of impact areas associated with the study area (Figure 5.9, Appendix M).

3.3.1 Habitat Descriptions and Mapping

A fauna habitat type broadly describes an area of habitat that is distinguishable by its vegetation, soil characteristics and land features from its surroundings, and is likely to host a different fauna assemblage to that found in other fauna habitats. Habitat delineation and mapping was based upon interpretation of aerial photography and landforms, habitat site assessments, soil descriptions, and the complementary detailed vegetation descriptions and mapping undertaken for this report (Section 5.2). Attention was paid to the likelihood that certain species of conservation significance may be present only in particular habitat types.

Habitat assessments were conducted at locations considered representative of each habitat patch (Figure 5.9). For each assessment, the following parameters were recorded:

- broad habitat type;
- digital photographs;
- landform type;
- soil colour, type and characteristics;
- type and extent of non-vegetative surface cover;
- type, height and percentage cover of vegetation in lower, middle and upper strata;
- observable fire history and evidence of any disturbance;
- presence and extent of leaf litter and coarse woody debris;
- presence of, or distance to, water sources;
- presence of significant microhabitats such as tree hollows and rocky outcrops; and
- notes on suitability for hosting conservation significant fauna.

A habitat condition rating was assigned to each habitat delineated based upon the criteria in Table 3.3.

Table 3.3 - Habitat condition assessment

Habitat Condition	Criteria
Excellent	Pristine or nearly so, no obvious sign of damage caused by modern humans or introduced fauna (cattle, feral cat, dog and rabbit). No signs of recent, extensive fires.
Very Good	Some relatively slight signs of damage caused by the activities of modern humans. eg. damage to tree trunks by repeated fires, no significant signs of introduced fauna or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of modern humans, including some obvious impact to vegetation structure such as that caused by low levels of grazing or by selective logging. Some tracks or secondary evidence of introduced fauna. Some signs of recent fires.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of modern humans such as partial clearing or very frequent fires. Presence of introduced fauna.
Very Poor	Severely impacted by grazing, introduced fauna, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management.
Completely Degraded	Areas that are completely or almost completely without vegetation communities and are heavily impacted by extensive fires and/or introduced species e.g. cow paddock

3.3.2 Fauna Observations

Opportunistic fauna observations were made during the survey to provide additional data to supplement the habitat mapping results. Observations consisted of direct observation of animals, as well as detection of secondary evidence including tracks, scats, remains and other traces. Sampling of the study area was undertaken by hand searching for cryptic species, which included searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Tracks, diggings, scats, burrows and nests were recorded wherever possible. Opportunistic fauna observations were also made while travelling within the study area.

3.3.3 Targeted Conservation Significant Fauna Surveying

Prior to the commencement of the survey as part of the desktop assessment, the preferred habitat of the conservation significant species potentially occurring in the study area was determined and used to assess the likelihood of occurrence (Section 4.7). The field survey was used to ground truth these results and, based on the actual habitats present, searches were undertaken to determine the presence of potential conservation significant species occurring. Search sites were selected on the likelihood of fauna habitat supporting conservation significant species. Effort was made to detect the tracks or scats of the Northern Quoll, Olive Python, Greater Bilby and Spectacled Hare-wallaby. Sites were also searched by hand for cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones.

3.4 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004). In all cases, animal species were identified in the field, and not captured and collected during the survey for later identification.

3.5 STUDY TEAM AND LICENCES

The flora, vegetation, and fauna assessments undertaken by *ecologia* was planned, coordinated, executed and reported by those summarised below in Table 3.4. DPaW licences to take flora and fauna for scientific purposes are also provided.

Table 3.4 – Study team and licences

Project Staff			
Name	**Qualification**	**Role**	**Project role**
Shaun Grein	B.Sc, Grad.Dip. Nat. Resources, MBA	Managing Director/Principal Scientist	Project management, reporting, QA
Andrew Craigie	B.Sc (Hons.), PhD (Botany)	Principle Botanist	Flora & vegetation field assessment, plant specimen identification, reporting (flora)
Tim McCabe	B. Sc Enviro Biology	Senior Zoologist	Fauna field assessment, reporting (fauna)
Licences - "Licence to Take Flora for Scientific Purposes"			
The flora, vegetation assessment and fauna assessment described in this report was conducted under the authorisation of the following licences issued by DBCA:			
Name		**Licence Number**	**Valid until**
Andrew Craigie		SL012354	30/04/2019

4 DESKTOP RESULTS

4.1 CLIMATE

The study area is located in the Pilbara region of Western Australia, which experiences an arid-tropical climate with two distinct seasons: a hot summer from October to April and a mild winter from May to September. Temperatures are generally high, with summer temperatures frequently exceeding 40°C. Light frosts occasionally occur inland during July and August.

Rainfall is generally localised and unpredictable (some years have recorded zero rainfall), and temperatures are high, resulting in annual evaporation exceeding rainfall by as much as 500 mm per year. Most of the Pilbara has a bimodal rainfall distribution; from December to March rains result from tropical storms producing sporadic thunderstorms. Tropical cyclones moving south also bring heavy rains. From May to June, extensive cold fronts move eastwards across the state and occasionally reach the Pilbara. These fronts usually produce only light rains. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses generally flow intermittently due to the short wet season (Beard 1975).

The nearest Bureau of Meteorology (BOM) station for which both rainfall and temperature data are available is Port Hedland Airport (Site No. 4032), located 82 km to the north of the study area. Port Headland Airport receives an average annual rainfall of 319.2 mm(BOM 2018), and has a typical Pilbara climate of hot summers with sporadic summer storms and warm dry winters (Figure 4.1). The current survey was conducted from 14th to 16th of May 2018, following a significantly higher than average rainfall period in January and a slightly lower period in February, March and April.

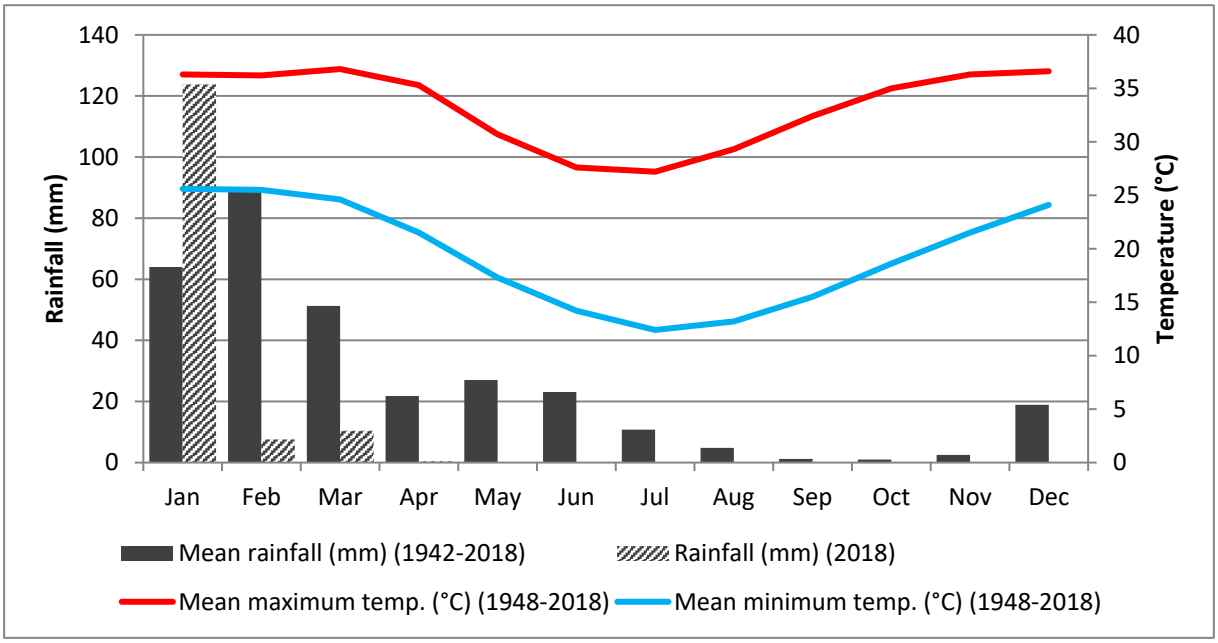


Figure 4.1 – Rainfall and temperature data for Port Headland Airport

4.2 IBRA 7 BIOGEOGRAPHIC SUBREGIONS

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into regions or bioregions on the basis of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2012a). The study area is situated within the Pilbara region according to IBRA 7 (DSEWPaC 2012a), which is further divided into four sub-regions: Hamersley, Fortescue Plains, Chichester and Roebourne. The study area is situated entirely within the Chichester sub-region (

Figure 4.2 – IBRA 7 subregions.

The Chichester sub region comprises the northern section of the Pilbara Craton. Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges. The climate is semi desert tropical and receives 300 mm of rainfall annually. Drainage occurs to the north via numerous rivers (e.g. De Grey, Oakover, Nullagine, Shaw, Yule and Sherlock). The sub regional area is 9,044,560 ha (Kendrick and McKenzie 2001).

The Chichester sub region is considered to have five ecosystems, associated with flora and vegetation, at risk (Kendrick and McKenzie 2001):

- *Heliotropium, Eragrostis* community on seepages near Mt Montagu, Chichester Range;
- Cracking clay communities of the Chichester Range and Mungaroona Range;
- Specific snakewood communities. Between Roy Hill and Marillana Stations;
- Saltbush Shrublands (de Grey River west side); and
- Saltbush community of the duplex plains - Mosquito Creek series (Nullagine).

4.3 LAND SYSTEMS

Van Vreeswyk *et al.* (2004a) undertook a regional inventory of the Pilbara rangelands to document the land systems present and their condition. The Pilbara Regional Inventory (PRI) covered 181,723 km^2, bounded by the Indian Ocean and Roebourne Plains to the north and west, extending to Broome in the north-east and the Ashburton River catchment in the south. The extent of each of the land systems vary greatly, with almost half the area comprised of just six land systems: Augustus, Little Sandy, Newman, Nita, Rocklea and Uaroo (Van Vreeswyk *et al.* 2004a).

The study area falls entirely within the Satirist land system (100%) (Table 4.1, Figure 4.3), which consists of five landforms:

1) Low rises and undulating plains with red shallow loams. Vegetation is primarily hummock grasslands of *Triodia wiseana* and other *Triodia* spp. with isolated *Acacia* spp.;
2) Calcrete plains with calcareous shallow loamy soils. Vegetation is primarily hummock grasslands of *Triodia wiseana* with scattered trees and shrubs;
3) Stony plains mostly non-gilgaied surfaces although some patches (10-30 m in size) with gilgai microrelief. Many to abundant pebbles and cobbles of mixed lithology sit over deep red/brown clays. Vegetation is primarily Hummock grasslands of hard spinifex (*T longiceps, T wiseana*) with isolated shrubs;
4) Gilgai plains with few to abundant ironstone pebbles over self-mulching cracking clays. Vegetation is primarily tussock grasslands of *Eragrostis xerophila* and *Eriachne benthamii* with isolated shrubs;
5) Drainage tracts and minor channels transect other landforms and have soils of red loamy earths and channels consistent with river bed soils. Vegetation is primarily hummock grasslands of *Triodia pungens* with scattered *Acacia* spp. and eucalypt trees. Larger channels may have fringing grassy woodlands with *Eucalyptus victrix*.

Table 4.1 – Land systems mapped at the study area

Land system	Description	Total area in Pilbara (ha)	Total area in study area (ha)	Proportion in study area (%)	Percentage of total extent within Pilbara (%)
Satirist	Stoney plains and low rises supporting hard spinifex grasslands and gilgai plains supporting tussock grasslands	37700	335	100%	0.89%

675000

700000

725000

7725000

7700000

7675000

7650000

7625000

M45/1260 study area

IBRA subregion

Chichester

Roebourne

ecologia ENVIRONMENT

Drawn: TM Project ID: 1739

Date: 6 June 2018 A3

N

0 3 6

Kilometers

Scale: 1:300,000

MGA94 (Zone 50)

IBRA subregions

Figure:

4.2

690000
696000
702000
7680000
7674000
7668000
7662000

M45/1260 study area

Land system

- Boolaloo Land System
- Boolgeeda Land System
- Capricorn Land System
- Macroy Land System
- Platform Land System
- River Land System
- Robe Land System
- Rocklea Land System
- Satirist Land System
- Talga Land System
- Uaroo Land System

ecologia ENVIRONMENT

Drawn: TM Project ID: 1739
Date: 6 June 2018 A3

N

0 0.5 1
Kilometers
Scale: 1:60,000
MGA94 (Zone 50)

Land systems

Figure: 4.3

4.4 PREVIOUS SURVEYS NEAR THE STUDY AREA

Several recent flora and fauna assessments have been conducted near the study area, including the adjacent Pilgangoora Project, the results of which are summarised in Table 4.2:

- Pilgangoora Project Area Flora, Vegetation and Fauna Assessment (MMWC Environmental 2016);
- Pilgangoora Project Baseline Vertebrate Fauna Survey (360 Environmental 2016b);
- Pilgangoora Project: Level 1 Short-Range Endemic (SRE) Fauna Assessment (Bennelongia 2016a);
- Pilgangoora Project: Level 1 Subterranean Fauna Assessment (Bennelongia 2016b);
- Pilgangoora Project: Pilbara Leaf-nosed Bat survey and roost searches (360 Environmental 2015) (360 Environmental 2016a);
- FMG North Star Vegetation and Flora Assessment (*ecologia* 2012a);
- FMG North Star Level 2 Terrestrial Vertebrate Fauna Assessment (*ecologia* 2012b).
- Wodgina DSO Project Flora and Vegetation Assessment (Outback Ecology 2009);
- Abydos DSO Project Flora and Vegetation Studies (Woodman 2012); and
- Abydos DSO Project terrestrial vertebrate fauna baseline surveys for Atlas Iron Limited (Outback Ecology 2011) (Bamford 2009).
- Altura Mining Limited Pilgangoora: Level 2 Flora and level 1 Fauna Assessment (Natural Area 2014)
- Altura Mining Limited Pilgangoora: Level 2 Flora and Level 2 Fauna Assessment (Natural Area 2016)

Table 4.2 – Flora, vegetation and fauna surveys conducted in the vicinity of the study area

Survey	Survey type	Location	Number of taxa	Conservation significant species recorded	Vegetation communities/fauna habitats	TEC/PEC
Pilgangoora Project Area Flora, Vegetation and Fauna Assessment (MMWC Environmental 2016)	Level 2 Flora and Vegetation Level 1 Fauna	ca. 90 km south-southeast of Port Hedland	195 (flora) 46 (fauna)	*Heliotropium muticum* (P1) Rainbow Bee-eater (IA) Pilbara Leaf-nosed Bat (VU) Western Pebble-mound Mouse (P4)	11 vegetation associations 4 fauna habitats	None
Pilgangoora Project Baseline Vertebrate Fauna Survey (360 Environmental 2016)	Level 2 Baseline Fauna	ca. 90 km south-southeast of Port Hedland	60	Rainbow Bee-eater (IA)	4 fauna habitats	NA
Pilgangoora Project: SRE Fauna Assessment (Bennelongia 2016a)	Level 1 SRE	ca. 82 km south-southeast of Port Hedland	23	No confirmed SRE species	4 SRE habitats	NA
Pilgangoora Project: Subterranean Fauna Assessment (Bennelongia 2016b)	Level 1 Subterranean Fauna	ca. 82 km south-southeast of Port Hedland	19 (stygofauna) 5 (troglofauna)	*Bathynella sp.* B25, Paramelitidae Genus 2 sp. B15 *Nocticola sp.* Coleoptera gen 1 sp. B08	Shallow aquifers	NA
Wodgina DSO Project (Outback Ecology 2009)	Level 2 Flora and Vegetation	ca. 100 km south of Port Hedland	122	*Terminalia supranitifolia* (P3)	12 vegetation associations	None
Abydos Direct Shipping Ore Project (Woodman 2012)	Level 2 Flora and Vegetation	ca. 100 km south-southeast of Port Hedland	263	*Euphorbia clementii* (P2) *Gymnanthera cunninghamii* (P3) *Heliotropium muticum* (P1) *Pityrodia* sp. Marble Bar (T)	10 vegetation associations	None
Abydos DSO Project Fauna Surveys (Bamford 2009, Outback Ecology 2011)	Level 2 Fauna and targeted searches	ca. 100 km south-southeast of Port Hedland	149	Northern Quoll Pilbara Olive Python Pilbara Leaf-nosed Bat Ghost Bat Western Pebble-mound Mouse Spectacled Hare Wallaby Rainbow Bee-eater	5 fauna habitats	NA

Survey	Survey type	Location	Number of taxa	Conservation significant species recorded	Vegetation communities/fauna habitats	TEC/PEC
FMG North Star (ecologia 2012a, ecologia 2012b)	Level 2 Flora and Vegetation Level 2 Fauna	ca. 100 km southeast of Port Hedland	453 (flora) 184 (fauna)	*Abutilon pritzelianum* (P1) *Acacia glaucocaesia* (P3) *Euphorbia clementii* (P2) *Goodenia nuda* (P4) *Gymnanthera cunninghamii* (P3) *Heliotropium muticum* (P1) *Pityrodia* sp. Marble Bar (T) *Ptilotus mollis* (P4) Northern Quoll (EN) Pilbara Leaf-nosed Bat (VU) Rainbow Bee-eater (IA) Fork-tailed Swift (IA) Pilbara Olive Python (VU)	33 vegetation associations 7 fauna habitats	None
Natural Area (2014)	Level 2 Flora Level 1 Fauna	ca. 86km southeast of Port Hedland	85 (flora) 10 (fauna)	*Stackhousia clementii* (P3)	5 vegetation types	None
Natural Area (2016)	Level 2 Flora Level 2 Fauna	ca. 86km southeast of Port Hedland	98 (flora) 51(fauna)	*Stackhousia clementii* (P3) Rainbow Bee-eater (IA) Western Pebble-mound Mouse (P4)	5 vegetation types 3 fauna habitats	None

4.5 FLORA

The NatureMap database search (40 km buffer) returned 301 vascular plant taxa from 51 families and 133 genera (Appendix B). The most diverse families were the Fabaceae (58 taxa), Poaceae (49 taxa), Malvaceae (25 taxa), and Amaranthaceae (17 taxa), while the most diverse genera included *Acacia* (18 taxa), *Tephrosia* (12 taxa), *Triodia* (10 taxa) and *Ptilotus* (10 taxa). This floristic composition is typical for the area and landforms present.

4.5.1 Significant Plant Species

Nineteen conservation significant plant taxa were identified within 20 km of the study area from the NatureMap search, and the TFPL and WAHERB database searches identified 20 species within 20 km of the study area (Table 4.5, Figure 4.4), including the Threatened taxon, *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4). Two Priority listed, *Heliotropium muticum* and *Stackhousia clementii*, species have been recorded in the close vicinity of the study area in previous surveys (Table 4.2). Records obtained from TPFL and WAHERB database searches are provided as Appendix D.

Habitat preferences and flowering times in Table 4.5 were derived, where available, from relevant taxonomic literature, FloraBase (Western Australian Herbarium 1998-2016), Threatened species profiles (SPRATs) (Threatened Species Scientific Committee 2016), or specimen data from Australia's Virtual Herbarium (AVH) (CHAH 2017). Herbarium catalogue numbers are provided if habitat information were derived from specimen data (AVH).

No conservation significant species have been recorded within the study area, although eight species are considered to potentially occur (likelihood rating '1') based on proximity of previous records and the possible presence of suitable habitat (Table 4.5). *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) has been recorded as near as 14 km from the southern boundary of the study area. A recent regional survey for this taxon conducted by *ecologia* (*ecologia* 2016) found it almost exclusively within the Capricorn Land System, often on ironstone hill slopes, with only six records outside of this within the Rocklea Land System. Neither of these land systems are associated with the study area. Therefore, it is considered unlikely that *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) occurs within the study area.

4.5.2 Introduced Plant Species

Twenty introduced species have been recorded near the study area (records from nearby surveys and the NatureMap database) (Table 4.3). Three of these (*Opuntia elata*, *Opuntia stricta*, and *Tamarix aphylla*) are Weeds of National Significance (DoE 2014) and Declared Pests (C3 Management) in Western Australia (DAFWA 2016).

Table 4.3 – Introduced plant species recorded near the study area

Species	WONS/WAOL Status
Aerva javanica (kapok bush)	Permitted - s11
Bidens bipinnata (bipinnate beggartick)	Permitted - s11
Calotropis procera (calotrope)	Permitted - s11
Cenchrus ciliaris (buffel grass)	Permitted - s11
Cenchrus setiger (Birdwood grass)	Permitted - s11
Chloris barbata (purpletop chloris)	Permitted - s11
Citrullus colocynthis (colocynth)	Permitted - s11
Cylindropuntia imbricata (cane cholla)	Declared Pest - C3
Cynodon dactylon (couch)	Permitted - s11
Digitaria ciliaris (summer grass)	Permitted - s11
Eragrostis minor (smaller stinkgrass)	Permitted - s11
Flaveria trinervia (speedy weed)	Permitted - s11
Indigofera oblongifolia (indigo)	Permitted - s11
Malvastrum americanum (spiked malvastrum)	Permitted - s11
Opuntia elata (riverina pear)	WONS (Declared Pest - C3)
Opuntia stricta (common prickly pear)	WONS (Declared Pest - C3)
Passiflora foetida var. *hispida* (stinking passion flower)	Permitted - s11
Sonchus oleraceus (common sowthistle)	Permitted - s11
Tamarix aphylla (tamarisk)	WONS (Declared Pest - C3)
Trianthema portulacastrum (giant pigweed)	Permitted - s11

4.6 VEGETATION

4.6.1 Pre-European Vegetation

The study area lies within Beard's (1975) Pilbara region of the Eremaean Botanical Province, part of a series of maps completed by Beard *et al.* from 1974 to 1981 throughout Western Australia, which was subsequently reinterpreted and updated to reflect the National Vegetation Information System (NVIS) standards (Shepherd *et al.* 2001). Two vegetation association (Shepherd *et al.* 2001) are mapped within the study area (Table 4.4, Figure 4.5).

The pre-European extent and current extent of the mapped vegetation associations have been calculated by the Statewide Vegetation Statistics (DPaW 2017). The extent of both vegetation associations is well above the 30% threshold below which species loss appears to accelerate exponentially, with associations below 30% within a bioregion classed as being critical assets (EPA 2000). Vegetation within the study area represents <0.001% of the current extent of each of these vegetation associations in the Chichester subregion.

Table 4.4 – Shepherd vegetation aassociations at the study area

Code	NVIS V description for vegetation mapped within study area	Pre-European extent in PIL1 (Chichester)	Percent remaining in PIL1 (Chichester)	% current extent protected for conservation (PIL1)	Area within study area (ha)	% post-European extent in study area
82	U *Eucalyptus leucophloia*\tree\6\rG^*Triodia wiseana* var. *brevifolia*,^*Triodia pungens*\hummock grass\2\i	360,666.90	99.90	0	2.18	<0.001
93	U *Grevillea pyramidalis*, *Hakea lorea*, *Senna* sp.\shrub\4\r	2,940,348.04	99.88	0.46	343.36	<0.001

4.6.2 Vegetation Surveys near the Study Area

Five vegetation types have been described for an area immediately adjacent to the eastern border of current study area (Natural Area 2014, 2016), none which corresponded to any known TEC or PEC. MMWC Environmental (2016) described 11 vegetation types in an area of approximately 1,600 ha, located immediately to the north and east of the study area. None of the described vegetation types identified by MMWC correspond to any TEC or PEC. One vegetation type (1a) was considered locally significant as it supports the Priority 3 species *Heliotropium muticum*, and vegetation units supporting *Eucalyptus victrix* were considered to represent potential groundwater dependant ecosystems.

4.6.3 Significant Vegetation

No Commonwealth or State listed TECs or PECs have been recorded within the 20 km search buffer, nor have any been recorded in surveys reviewed as part of this desktop study.

4.6.4 Restricted Land Forms

An assessment of aerial imagery and review of background information did not identify any unusual or restricted landforms within the study area.

Table 4.5 – Threatened and Priority Flora species records from database searches

Status	Taxon	Source	Habitat	Flowering period	Notes	Likelihood of occurrence (including current survey)
T	*Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	TPFL	Base of sandstone hill slopes with skeletal brown sandy loam over sandstone.	July to September	Habitat not present.	Unlikely (3)
1	*Abutilon* sp. Pritzelianum (S. van Leeuwen 5095)	TPFL	Coastal or near-coastal sand dunes, margins of estuaries, coastal plains. Red sand or clay.	Not available	Habitat not present.	Unlikely (3)
1	*Acacia leeuweniana*	TPFL	Skeletal granitic soil over massive granite.	Not available	Habitat not present.	Unlikely (3)
1	*Heliotropium muticum*	TPFL, MMWA (2016)	Plains. Flat red silt sand on a low-lying floodplain.	Not available	Habitat possibly present; nearby records.	Possible (1)
1	*Rothia indica* subsp. *australis*	TPFL	Sandy soils. Sandhills and sandy flats. Near-coastal sands.	April to August	Habitat not present.	Unlikely (3)
2	*Euphorbia clementii*	TPFL	Gravelly hillsides, stony grounds.	April to June	Habitat possibly present; nearby records.	Recorded
2	*Stylidium weeliwolli*	TPFL	Gritty sand soil, sandy clay. Edge of watercourses.	August to September	Habitat not present.	Unlikely (3)
3	*Acacia levata*	TPFL	Sand or sandy loam over granite. Low rocky hills.	May	Habitat possibly present; nearby records.	Possible (1)
3	*Eragrostis crateriformis*	TPFL	Clayey loam or clay. Flats, creek banks, depressions.	January to July	Habitat possibly present; nearby records.	Possible (1)
3	*Fimbristylis sieberiana*	TPFL	Riparian habitats, edges of pools.	May to June	Habitat not present.	Unlikely (3)
3	*Gomphrena leptophylla*	TPFL	Sand, sandy to clayey loam, granite, quartzite. Open flats, sandy creek beds, edges salt pans & marshes, stony hillsides.	March to September	Habitat possibly present; nearby records.	Possible (1)
3	*Gymnanthera cunninghamii*	TPFL	Permanent or semi-permanent water-courses in sandy soils.	January to December	Habitat not present.	Unlikely (3)
3	*Nicotiana umbratica*	TPFL	Shallow soils. Rocky outcrops.	April to June	Habitat not present.	Unlikely (3)
3	*Phyllanthus hebecarpus*	TPFL	Sandy areas, granite domes.	April to August	Habitat not present.	Unlikely (3)
3	*Stackhousia clementii*	Natural Area (2016)	Skeletal soils. Sandstone hills.	Not available	Habitat possibly present; nearby records.	Possible (1)
3	*Terminalia supranitifolia*	TPFL	Sand. Among basalt rocks. Rocky cliffs.	July or December	Habitat not present.	Unlikely (3)
3	*Triodia basitricha*	TPFL	Rocky and gravelly slopes of mountains or low hills.	Not available	Habitat not present.	Unlikely (3)
3	*Triodia chichesterensis*	TPFL	Sand or loam over rocky or gravelly substrates, often with quartzite.	Not available	Habitat possibly present; nearby records.	Recorded
4	*Bulbostylis burbidgeae*	TPFL	Granitic soils. Granite outcrops, cliff bases.	March to August	Habitat not present.	Unlikely (3)
4	*Goodenia nuda*	TPFL	Seasonally inundated clay soils and drainage lines	April to August	Habitat possibly present; nearby records.	Possible (1)
4	*Ptilotus mollis*	TPFL	Steep rocky slopes, massive ironstone formations.	May to September	Habitat not present.	Unlikely (3)

660000 680000 700000 720000 740000

7720000 7700000 7680000 7660000 7640000 7620000 7600000

M45/1260 study area

Taxon

- Abutilon sp. Pritzelianum
- Acacia leeuweniana
- Acacia levata
- Bulbostylis burbidgeae
- Eragrostis crateriformis
- Euphorbia clementii
- Fimbristylis sieberiana
- Gomphrena leptophylla
- Goodenia nuda
- Gymnanthera cunninghamii
- Heliotropium muticum
- Nicotiana umbratica
- Phyllanthus hebecarpus
- Pityrodia sp. Marble Bar (T)
- Ptilotus mollis
- Rothia indica subsp. australis
- Stylidium weeliwolli
- Terminalia supranitifolia
- Triodia basitricha
- Triodia chichesterensis

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N

0 3.25 6.5
Kilometers
Scale: 1:325,000
MGA94 (Zone 50)

Threatened and Priority Flora species records near the study area

Figure: 4.4

690000
696000
702000
7680000
7674000
7668000
7662000

93
82
619

M45/1260 study area

Vegetation association

82
93
619
626

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N

0 0.5 1
Kilometers
Scale: 1:60,000
MGA94 (Zone 50)

Pre-European vegetation

Figure:
#

4.7 FAUNA

A total of 301 terrestrial vertebrate species were recorded from the desktop study, including 48 mammals (9 introduced), 131 birds, 112 reptiles, and 10 amphibians (Table 4.6). NatureMap records of all fauna recorded from within 30 km and BirdLife data of birds records with 50 km are presented in Appendices E and F.

Table 4.6 – Previous fauna records

Survey location and author(s)	Mammals	Birds	Reptiles	Amphibians
Biological survey				
Pilgangoora Project Level 1 Fauna (MMWC Environmental 2016/360 Environmental)	13	27	6	0
Pilgangoora Baseline Vertebrate Fauna Survey Level 2 (360 Environmental 2016)	3	22	30	0
Abydos DSO Project for Atlas Iron (Outback Ecology 2011) (Bamford 2009)	21	75	45	5
FMG North Star Level 2 Fauna Assessment (*ecologia* 2012)	22	81	75	6
Altura Pilgangoora Level 2 Fauna Assessment (Natural Area 2016)	9	22	21	0
Databases				
DBCA NatureMap	48	131	112	10
Birdlife Australia Birdata		91		
DBCA Threatened and Priority Fauna Search	7	4	1	0
DoEE EPBC Act Protected Matters Search	4	14	1	

DBCA records of conservation significant fauna records within 30 km of the study area are presented in Appendix E. Twenty-four of the species identified from the literature review and database searches are considered conservation significant (Table 4.7) (Figure 4.6). Due to the large search areas used many species would not occur within habitats of the study area (e.g. migratory shorebirds, Marine listed species). For this reason, species that have no record within the vicinity and no relevant habitat such as the Osprey and Sandpipers, have been omitted from further discussion. An assessment of likelihood of occurrence for relevant conservation significant fauna species recorded during the desktop assessment was conducted by examining:

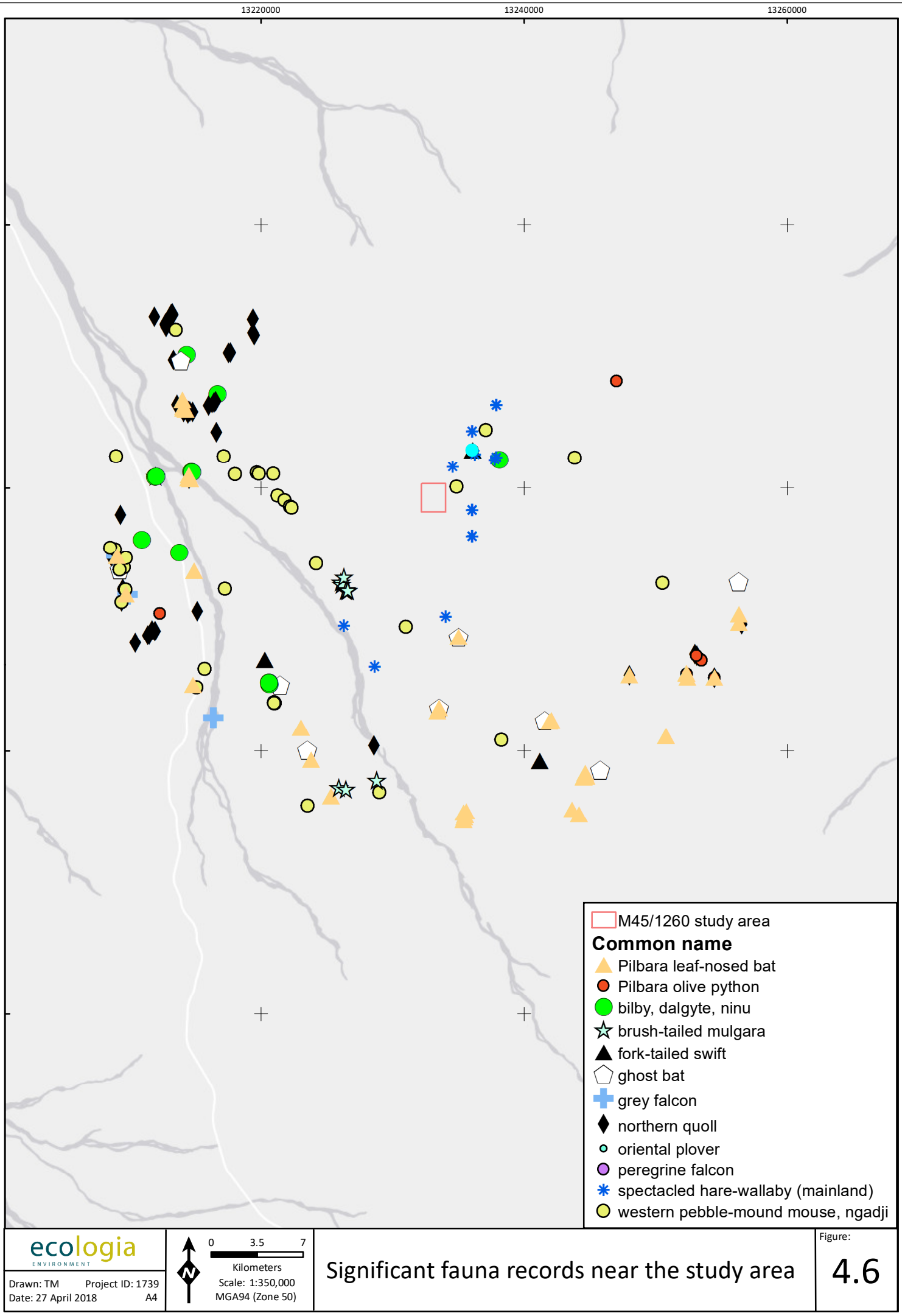
- Fauna habitats present within the study area;
- Distance of previously recorded significant species based on publicly available records;
- Frequency of occurrence of conservation significant species records; and
- Time passed since conservation significant species were recorded.

Each relevant conservation significant vertebrate fauna species potentially occurring over the study area was assigned a likelihood of occurrence rating based on the four categories described in Table 3.1. Results are presented in Table 4.7. The Western Pebble-mound Mouse, Rainbow Bee-eater and Pilbara Leaf-nosed Bat were all assessed as likely to occur over the study area.

Bennelongia (2016a) surveyed a large area immediately to the Northeast of the study area and concluded that no listed or confirmed SRE invertebrate species were likely to occur. As the study area encompasses comparable (and adjacent) habitats no listed or confirmed SRE invertebrate species are likely to occur over the study area. Similarly, of the subterranean invertebrate species identified by Bennelongia (2016b) stygofauna are likely to be found in the transmissive alluvial habitats along larger creeklines such as Pilgangoora and Chinnamon Creeks, while the troglofauna records were associated with Banded Iron Formations (BIFs). Both these habitats are unlikely to be present over the study area. In addition all stygofauna and troglofauna taxa recorded by Bennelongia (2016a) are either known to, or expected to have, wider distributions than the immediate study area (Bennelongia 2016b).

Table 4.7 – Significant vertebrate fauna species records from the database searches

Common Name	Species	WA Status	EPBC Act Status	Records	Latest Record	Notes	Likelihood of occurrence
Mammals							
Northern Quoll	*Dasyurus hallucatus*	EN	EN	97	2016	Records from vicinity but no suitable rocky denning habitat present.	Possible (2)
Brush-tailed Mulgara	*Dasycercus blythi*	P4		14	2013	Records from vicinity. Mature suitable unburnt habitat present.	Possible (2)
Greater Bilby	*Macrotis lagotis*	VU	VU	12	2016	Records from vicinity. No suitable burrowing habitat present.	Possible (2)
Spectacled Hare-wallaby	*Lagorchestes conspicillatus leichardti*	VU	VU	264	1996	Records from vicinity. Suitable unburnt habitat present.	Possible (2)
Western Pebble-mound Mouse	*Pseudomys chapmani*	P4		33	2016	Records from vicinity and stony habitat present. Inactive mounds recorded.	Possible (1)
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia (Pilbara)*	VU	VU	195	2017	Records from vicinity. No roost habitat but foraging habitat present.	Possible (1)
Ghost Bat	*Macroderma gigas*	VU	VU	12	2016	Records from vicinity. No roost habitat but foraging habitat present.	Possible (2)
Birds							
Night Parrot	*Pezoporus occidentalis*	CR	EN	0		No records within 30 km. No suitable unburnt habitat likely to be present.	Unlikely (3)
Peregrine Falcon	*Falco peregrinus*	OS		2	2013	Two records within 30 km. Widespread species that may overfly the study area.	Possible (2)
Grey Falcon	*Falco hypoleucos*	VU		3	2015	Three records within 30 km. Widespread species that may overfly the study area.	Possible (2)
Barn Swallow	*Hirundo rustica*	IA	IA	0		No records within 30 km. Few regional records. Habitat unlikely to be present.	Unlikely (3)
Rainbow Bee-eater	*Merops ornatus*	IA	M	1	2016	Records from vicinity. Suitable nesting habitat in minor drainage line.	Possible (1)
Grey Wagtail	*Motacilla cinerea*	IA	IA	0		No records within 30 km. Few regional records. Vagrant.	Unlikely (3)
Yellow Wagtail	*Motacilla flava*	IA	IA	0		No records within 30 km. Few regional records. Vagrant.	Unlikely (3)
Fork-tailed Swift	*Apus pacificus*	IA	IA	15	2011	May overfly the study area without utilising any of the habitats present.	Possible (2)
Eastern Curlew	*Numenius madagascaiensis*	IA	CR	0		Records in vicinity. However, no coastal, wetland or estuarine habitat present.	Unlikely (3)
Oriental Plover	*Charadrius veredus*	IA	IA	1	1999	Just one record within 30 km. No coastal, wetland or estuarine habitat present.	Unlikely (3)
Oriental Pratincole	*Glareola maldivarum*	IA	IA	0		No records within 30 km. Suitable plains habitat may be present.	Unlikely (3)
Reptiles							
Pilbara Olive Python	*Liasis olivaceus barroni*	VU	VU	9	2015	No suitable gorge, gully, riverine or permanent water habitat present.	Unlikely (3)



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Significant fauna records near the study area

Figure: 4.6

5 FIELD SURVEY RESULTS

5.1 FLORA

5.1.1 Floristic Diversity

122 sub-generic vascular plant taxa (including species, infraspecific taxa, and phrase names) representing 71 genera and 27 families were recorded within the study area (Appendix H). Of these, two were Priority listed flora species and three were introduced. The most diverse families were the Poaceae (31 taxa), Fabaceae (25 taxa), Malvaceae (12 taxa), Amaranthaceae (10 taxa), and Goodeniaceae (six taxa), while the most diverse genera were *Acacia* (nine taxa), *Ptilotus* (eight taxa), *Triodia* (six taxa), *Eriachne* (four taxa), and *Euphorbia* (four taxa).

5.1.2 Introduced Species

Three introduced species were recorded within the study area: *Cenchrus ciliaris* (buffel grass), *Cenchrus setiger* (Birdwood grass), and *Echinochloa colona* (awnless barnyard grass). *Cenchrus ciliaris* and *C. setiger* were primarily associated with the minor creek line and adjacent floodplains, while *E. colona* was recorded in low abundance from gilgai claypans.

5.1.3 Significant Species

No EPBC Act (1999) listed Threatened Flora species or WC Act (1950) listed Threatened Flora species were recorded within the study area. No suitable habitat (or suitable land system) for the Endangered *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) was identified within the study area.

Two State listed Priority Flora species were recorded: *Euphorbia clementii* (Priority 3) (Figure 5.1) and *Triodia chichesterensis* (Priority 3) (Figure 5.2). *Euphorbia clementii* was recorded from 27 locations within the study area, totalling approximately 250 individuals (Figure 5.3). *Triodia chichesterensis* was recorded from the eastern border of the study area where it formed the dominant component of the vegetation unit present on stony quartzite plains (Figure 5.3).

5.2 VEGETATION

Six vegetation units were described and mapped (Table 5.1, Figure 5.4, Figure 5.5). The study area consists primarily of stony plains dominated by vegetation unit S1 (*Acacia inaequilatera* and *A. ancistrocarpa* open shrubland over *Triodia longiceps* [with occasional patches where *T. brizoides* or *T. lanigera* are dominant] hummock grassland). These are interspersed with gilgai (small clay depressions) dominated by the S2 unit (*Neptunia dimorphantha* and *Sida fibulifera* low open shrubland over *Eriachne benthamii* and *Cynodon convergens* open grassland), and minor drainage lines dominated by unit S3 (*Acacia acradenia*, *A. ancistrocarpa*, *A. tumida*, and *Petalostylis labicheoides* open shrubland over *Triodia epactia* hummock grassland). Vegetation unit S4 (*A. inaequilatera* sparse shrubland over *Triodia chichesterensis* open hummock grassland) is restricted to the eastern border of the study area on stony plains with quartzite.

A minor creek line runs through the centre of the study area supporting unit W1 (*Eucalyptus victrix* and *Corymbia hamersleyana* open woodland over *Acacia colei* sparse shrubland over *T. epactia* sparse hummock grassland) and W2 (*C. hamersleyana* open woodland over *A. acradenia* and *A. ancistrocarpa* sparse shrubland over *T. epactia* open hummock grassland). Unit W2 is very similar to unit S3 but contains *C. hamersleyana* dominant in the upper stratum.

5.2.1 Significant Vegetation

No State or Nationally listed TECs or PECs were recorded within the study area. Vegetation unit S4 may be considered locally significant as it supports the Priority 3 species *Triodia chichesterensis*,

which is restricted to the central Chichester IBRA subregion. Vegetation unit W1 supports *Eucalyptus victrix*, which is a facultative phreatophyte, that is, it is potentially groundwater dependant in situations in circumstances where surface water is unavailable.

5.2.2 Vegetation Condition

Vegetation condition across most of the study area was assessed as 'Very Good' to 'Excellent' (325.23 ha) (Figure 5.6), with no or minimal weed invasion, insignificant grazing, and occasional vehicle tracks. Vegetation within the creek line and surrounding floodplain was rated as 'Good' due to more significant grazing and trampling by cattle and higher weed (*C. ciliaris* and *C. setiger*) abundance (20.32 ha).



Figure 5.1 – *Euphorbia clementii* (P3) habit (left), flowers and fruit (right).



Figure 5.2 – *Triodia chichesterensis* (P3) growing on stony quartzite plains.

694000
694500
695000
695500
7669500
7669000
7668500
7668000
7667500

M45/1260 study area
Triodia chichesterensis (P3) population extent
Euphorbia clementii (P3)

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N

0 0.05 0.1
Kilometers
Scale: 1:7,000
MGA94 (Zone 50)

Priority Flora species records within the study area

Figure:
5.3

Table 5.1 – Vegetation units within the study area

Code	Description (NVIS V)	Representative sites	Landforms	Vegetation condition	Area (ha)
S1	*Acacia inaequilatera* and *Acacia ancistrocarpa* mid open shrubland over *Triodia longiceps* (±*T. lanigera*, *T. brizoides*, *T. epactia*) open hummock grassland.	8, 11, 13, 14, 15, 19, 23, 26	Stony plains, undulating plains	Very Good to Excellent	289.88 (83.9%) (mosaic)
S2	*Neptunia dimorphantha* and *Sida fibulifera* low open shrubland over *Eriachne benthamii* and *Cynodon convergens* open grassland.	3, 5, 12, 24	Gilgai, claypans	Very Good to Excellent	
S3	*Acacia acradenia*, *A. ancistrocarpa*, *A. tumida* var. *pilbarensis,* and *Petalostylis labicheoides* mid open shrubland over *Triodia epactia* (±*T. wiseana*) hummock grassland.	4, 6, 7, 10, 16, 18, 20, 22, 25	Drainage lines, floodplains	Very Good to Excellent	31.96 (9.2%)
S4	*Acacia inaequilatera* sparse mid shrubland over *Triodia chichesterensis* (P3) open hummock grassland.	21, 27	Low stony quartzite rises	Very Good to Excellent	3.37 (1.0%)
W1	*Eucalyptus victrix* and *Corymbia hamersleyana* low open woodland over *Acacia colei* mid sparse shrubland over *Triodia epactia* sparse hummock grassland.	1	Minor creek	Good (weeds, grazing)	0.54 (0.2%)
W2	*Corymbia hamersleyana* low open woodland over *Acacia acradenia* and *A. ancistrocarpa* mid sparse shrubland over *Triodia epactia* (±*T. wiseana*, *T. longiceps*) open hummock grassland.	2, 9, 17, 28	Minor creek, drainage lines	Good (weeds, grazing)	19.77 (5.7%)



S1 - *Acacia inaequilatera* and *Acacia ancistrocarpa* mid open shrubland over *Triodia longiceps* (±*T. lanigera*, *T. brizoides*, *T. epactia*, *T. wiseana*) open hummock grassland.



S2 - *Neptunia dimorphantha* and *Sida fibulifera* low open shrubland over *Eriachne benthamii* and *Cynodon convergens* open grassland.



S3 - *Acacia acradenia*, *A. ancistrocarpa, A. tumida* var. *pilbarensis,* and *Petalostylis labicheoides* mid open shrubland over *Triodia epactia* (±*T. wiseana*) hummock grassland.

Figure 5.4 – Representative photographs of vegetation units within the study area.



S4 - *Acacia inaequilatera* mid sparse shrubland over *Triodia chichesterensis* (P3) open hummock grassland.



W1 - *Eucalyptus victrix* and *Corymbia hamersleyana* low open woodland over *Acacia colei* mid sparse shrubland over *Triodia epactia* sparse hummock grassland.



W2 - *Corymbia hamersleyana* low open woodland over *Acacia acradenia* and *A. ancistrocarpa* mid sparse shrubland over *Triodia epactia* (±*T. wiseana*, *T. longiceps*) hummock grassland.

Figure 5.4 (cont.)

694500 695250

7669500 7668750 7668000 7667250

S1/S2 S3 W2 W1 S4

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 26 27 28

M45/1260 study area

Vegetation assessment site

Vegetation unit

- Acacia acradenia, A. ancistrocarpa and Petalostylis labichioides open shrubland over Triodia epactia (±T. wiseana) hummock grassland.
- Acacia inaequilatera shubland over Triodia longiceps hummock grassland (stony plains) and Eriachne benthamii open grassland (gilgai)
- Acacia inaequilatera sparse shrubland over Triodia chichesterensis (P3) open hummock grassland.
- Corymbia hamerslayana open woodland over Acacia acradenia and A. ancistrocarpa mid sparse shrubland over Triodia epactia (±T. wiseana, T. longiceps) open hummock grassland.
- Eucalyptus victrix and Corymbia hamersleyana open woodland over Acacia colei mid sparse shrubland over Triodia epactia sparse hummock grassland.

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N

0 0.05 0.1
Kilometers
Scale: 1:7,000
MGA94 (Zone 50)

Vegetation units within the study area

Figure: 5.5

694500

695250

7669500

7668750

7668000

7667250

M45/1260 study area

Vegetation condition

Good (weeds, grazing)

Very Good - Excellent (minimal grazing, few to no weeds)

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N

0 0.05 0.1

Kilometers

Scale: 1:7,000

MGA94 (Zone 50)

Vegetation condition within the study area

Figure:

5.6

5.3 FAUNA AND HABITATS

5.3.1 Broad Fauna Habitats

Detailed fauna habitat assessments were undertaken at 17 representative sites within the study area (Figure 5.9), with track logs, habitat assessment sheets and photographs provided in Appendices K and L. Ideally habitat descriptions should be interpreted in conjunction with the vegetation data recorded for the study area (Section 5.2), which contains additional information on floristic assemblages present. Two broad fauna habitat types were recorded within the study area (Table 5.2), both of which are considered widespread and typical of the bioregion.

Table 5.2 – Fauna habitats identified within the study area

Habitat	Proportion in study area (ha)	Percentage extent in study area (%)
Stony Plains	313.8	94.5%
Minor Drainage Lines	18.2	5.5%

Minor Drainage Lines

The Minor Drainage Lines habitat is characterised by small drainage lines, as distinct to the broad, sandy water channels of Riverine habitat such as the Turner River. Two areas of Minor Drainage Lines habitat occur within the study area representing just 5.5% of the total area (18.2 ha). This habitat typically supports a thin band of scattered *Corymbia hamersleyana* eucalypts as well as an open or closed shrubland of *Acacia* spp. over hummock grasslands of *Triodia epactia*.

The linear configuration of drainage lines links resources and habitats, and is therefore important for enabling the movement and dispersal of fauna throughout the landscape (McKenzie and Bullen 2009b; Burbidge *et al.* 2010). The Minor Drainage Lines habitat itself is also likely to be a temporary source of food, e.g. seeds for granivorous birds, as it retains water for longer periods than the surrounding plains (Burbidge *et al.* 2010). This vegetation structure offers relatively wide ranges of microhabitats with denser cover, small hollows, and more mesic and shadier conditions, occasionally with free-standing water. Scattered eucalypt trees in this habitat type are generally larger than trees in the surrounding habitats and larger, more suitable, hollows are available for nesting and/or denning. Associated alluvial soils are also generally more suitable for burrowing. Consequently, more species were recorded within the Minor Drainage Lines habitat than any other habitats within the study area.

Stony Plains

Stony Plains habitat is dominant within the study area covering 94.5% (313.8 ha). This habitat type is well represented within the region and is found broadly throughout surrounding land systems. Within the Satirist Land System, van Vreeswyk *et al.* (2004b) describes stony plains as mostly non-gilgai surfaces with some gilgai microrelief which is consistent with what is found within the study area. This habitat type is characterised by occasional *Corymbia hamersleyana*, scattered low woodlands consisting of Acacia spp. over hummock grasslands of *Triodia longiceps*, *T. wiseana* with tussock grasslands in gilgai areas. The stony substrate and spinifex cover provide few microhabitats and the *Acacia* woodlands does not support tree hollows, few logs, limited leaf litter and sparse vegetation.

The value of Stony Plain habitat to native fauna assemblages in general is closely related to its fire history, with areas that retain a mosaic of fire ages often providing the best habitat (Woinarski 1999; Parr and Andersen 2006; Southgate *et al.* 2007). Recently burnt habitat may be used for foraging, while long unburnt areas may be used for shelter for several species. Greater Bilby and Brush-tailed

Mulgara occur in plains habitat of sand (Spinifex Sandplain) or other friable substrates that facilitates the construction of burrows. None of these substrates occur within the Stony Plains habitat in the study area and there was no evidence of these species was found. The Stony Plains habitat over most of the study area was assessed as Excellent to Very Good condition (Appendix L).



Minor Drainage Line (Site S01)

Stony Plains (Site S06)

Figure 5.7 – Photographs of broad fauna habitats of the study area

5.3.2 Fauna Assemblage

Thirty-three terrestrial vertebrate species were recorded during the reconnaissance survey including 27 birds, three mammals (2 introduced) and three reptiles (Table 5.3). One disused mound of the Pebble-mound Mouse (Priority 4) was also recorded (Figure 5.8; Figure 5.9).

A total of one-hundred and six records were made with 27 species recorded from established sites and an additional six species recorded from within the general study area. No frogs were recorded, and no surface water was found to be present. Twenty-five species were recorded from the Minor Drainage Line habitat, with 18 species recorded from the Stony Plains habitat, with opportunistic observations of the study area accounting for six species. Feral cat tracks were observed in the minor drainage line.

A single, long unused mound of the Priority 4 listed species Western Pebble-mound Mouse was recorded, which was assessed as being inactive due to the immediate area being overgrown and no presence fresh excavations (Figure 5.8). No roosting and foraging caves for the Pilbara Leaf-nosed Bat or Ghost Bat were observed from the study area, although further investigations using SM2BAT echolocation detectors would be required to determine whether either bat species utilises for area for foraging. No evidence of the Northern Quoll was recorded, and no suitable denning or foraging habitat is present.

The potential species makeup of the study area as determined from database searches is provided in Appendices E and F, and the species recorded during the survey are presented in Table 5.3.



Figure 5.8 – Disused inactive pebble mound of the Western Pebble Mound Mouse (PM1)

694000
695000
7670000
7669000
7668000
7667000

7
6
4
5
8
17
PM1
3
9
1
2
16
14
12
13
11
15
10

M45/1260 study area
Disused Western Pebble-mound Mouse Mound
Fauna Habitat Sites

Habitat Type

Minor Drainage Line
Stony Plains

ecologia ENVIRONMENT

Drawn: TM Project ID: 1739
Date: 6 June 2018 A3

N

0 0.075 0.15
Kilometers
Scale: 1:8,000
MGA94 (Zone 50)

Broad fauna habitats within the study area

Figure: 5.9

Table 5.3 – Vertebrate fauna species recorded during the survey

Common Name	Scientific Name	Minor Drainage Lines					Stony Plains												Study Area
		S01	S02	S13	S14	S16	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S15	S17	
MAMMALS																			
Euro	*Macropus robustus*	X	X	X				X				X	X	X					X
Cattle	*Bos taurus*	X	X			X						X			X				X
Feral Cat	*Felis catus*	X																	
BIRDS																			
Crested Pigeon	*Ocyphaps lophotes*		X	X			X											X	X
Spinifex Pigeon	*Geophaps plumifera*			X				X		X	X				X				X
Diamond Dove	*Geopelia cuneata*		X	X													X		X
Wedge-tailed Eagle	*Halieetus luecogaster*																		X
Whistling Kite	*Haliastur sphenurus*																		X
Black Kite	*Milvus migrans*																X		X
Nankeen Kestrel	*Falco cenchroides*			X											X				X
Brown Falcon	*Falco berigora*					X													
Little Button-quail	*Turnix velox*			X				X			X					X			X
Galah	*Eolophus roseicapillus*	X	X											X					X
Cockatiel	*Nymphicus hollandicus*	X		X								X							X
Budgerigar	*Melopsittacus undulatus*			X									X						X
White-winged Fairy-wren	*Malurus leucopterus*				X														
Singing Honeyeater	*Lichenostomus virescens*	X	X		X							X							X

Common Name	Scientific Name	Minor Drainage					Stony Plains												Study Area
		S01	S02	S13	S14	S16	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S15	S17	
Grey-headed Honeyeater	*Lichenostomus keartlandi*	X	X																X
Black Honeyeater	*Certhinyx niger*	X	X																
Yellow-throated Miner	*Manorina flavigula*	X	X										X						X
Crimson Chat	*Ephianura tricolor*																		X
Black-faced Woodswallow	*Artamus cinereus*		X	X				X				X				X			X
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X				X			X									X
Magpie	*Gymnorhina tibicen*	X																	X
Pied Butcherbird	*Cracticus nigrogularis*	X				X													
Willie Wagtail	*Rhipidura leucophrys*	X													X	X			X
Torresian Crow	*Corvus orru*																		X
Zebra Finch	*Taeniopygia guttata*		X						X				X			X	X		X
Painted Finch	*Emblema pictum*				X														X
Australasian Pipit	*Anthus novaeseelandiae*																		X
REPTILES																			
Ring-tailed Dragon	*Ctenophorus caudicinctus*				X			X	X				X			X			X
Varied Dtella	*Gehyra variegata*																		X
Sand Monitor	*Varanus gouldii*																	x	

5.4 CONSERVATION SIGNIFICANT FAUNA

5.4.1 Vertebrate species of conservation significance likely to occur

Western Pebble-mound Mouse *(Pseudomys chapmani)* (Priority 4 listed by DPaW)

The Western Pebble-mound Mouse constructs distinctive mounds of pebbles around their burrows (Anstee *et al.* 1997). The species is patchily distributed in the Pilbara, but known to have a preference for hilly and/or rocky landscapes (Anstee and Armstrong 2001; Ford and Johnson 2007). When first described it was thought that the range and abundance of this species had decreased dramatically. Since that time, however, it has been recorded on numerous occasions (usually associated with mining development surveys in the Pilbara), and is widespread in the bioregion. Its status has subsequently been downgraded from Schedule 1 under the WC Act to Priority 4 (Start *et al.* 2000).

Thirty-four records of the Western Pebble-mound Mouse occur within 25 km of the study area (Figure 4.6), with the closest within 850 m of the study area. Two active mounds were recorded extremely close to the study area during a recent survey by Natural Area (2016) and one old, disused mound was recorded during this survey (Figure 5.8) with the mound location shown as PM1 in Figure 5.9. The species occurs on skeletal soils that provide pebbles of a suitable size for the species and are usually found on gentle slopes and spurs vegetated by hard spinifex. The study area is likely to support the species within the Stony Plains habitat.

Pilbara Leaf-nosed Bat *(Rhinonicteris aurantia* Pilbara) (Vulnerable under EPBC Act and WC Act)

The Pilbara Leaf-nosed Bat has very restrictive requirements, such as caves and disused mines with hot to very hot and humid roost sites at 28° to 32° C and 96% to 100% relative humidity (Armstrong 2001; Churchill 2008). The species is thought to have a disjunct Pilbara population (Armstrong 2001). During the Pilbara winter dry months, preceding the heavy rains of summer, Pilbara Leaf-nosed Bat are thought to contract to the deepest mines and caves that maintain microclimates suitable for roosting (Armstrong 2001) (Bullen and McKenzie 2011) (van Dyck and Strahan 2008). During the hotter summer wet months, the species has greater ability to disperse through the landscape.

Over a hundred records of Pilbara Leaf-nosed Bat calls have been recorded within 30 km of the study area (Figure 4.6), and comprehensive surveys for the species were undertaken for the Pilgangoora Project at 35 sites over the region by 360 Environmental (2015) and 360 Environmental (2016a) just to the northeast of the study area.

An analysis of the timing of Pilbara Leaf-nosed Bat calls by 360 Environmental (2015) and 360 Environmental (2016a) indicated an unknown diurnal roost within the vicinity. A diurnal roost is one that the bats roost in during daylight hours for part or all of the year and is differentiated from a foraging location which is used temporarily during the night. Without further assessments permanent diurnal roosts are considered to be maternity sites. 360 Environmental (2016a) in conjunction with Bat Call WA identified a new Pilbara Leaf-nosed Bat diurnal roost site within a historical underground mine close to the Turner River East branch and is known as the East Turner River Roost (ETRR). This is the only known Pilbara Leaf-nosed Bat roost in the region. The population estimate was between 25 and 50 individuals representing one of the smallest diurnal roosts in the Pilbara (360 Environmental 2016a), and the site is assumed to be a maternal roost until proven otherwise.

The creek lines in the vicinity of the study area have been shown to provide foraging habitat for the Pilbara Leaf-nosed Bat supporting 'Low' to 'Medium' levels of activity (360 Environmental 2016a). Utilising the Pilbara Leaf-nosed Bat foraging habitat rating matrix employed by 360 Environmental (2015) (with ratings ranging from Habitat Rating (HR) Zero to Five) the Minor Drainage Line habitat over the study area is rated 'HR02'. That is; the species may occasionally forage in these areas due to the presence of suitable vegetation and/or seasonal water and may also use these areas as a flyway.

Rainbow Bee-eater *(Merops ornatus)* (Protected under international agreements)

The Rainbow Bee-eater was removed from the list of migratory species under section 209 of the EPBC Act on 9th June 2016, however, still appears on Schedule 5 of the WC Act as 'Migratory birds protected under an international agreement'. In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or summer visitor. The Rainbow Bee-eater migrates between southern Australia and north as far as Japan. Southern populations migrate northward from February to April and return to their breeding grounds in September and October (Pizzey and Knight 2003). The Rainbow Bee-eater occupies numerous habitats including open woodlands with sandy loamy soil, sand ridges, sandpits, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests (Pizzey and Knight 2003).

DBCA Threatened and priority fauna searches returned no records within 25 km radius of the study area although the PMST search recognized its presence within a 50 km buffer. The Rainbow Bee-eater was found by Natural Area (2016), MMWC Environmental (2016) and 360 Environmental (2016b) during field surveys on nearby tenements. It was not recorded during the current survey and in light of its broad habitat requirements, the fact that it is a common migrant, and nearby records it is considered likely to occur in all habitats present over the study area and may utilise banks along Drainage Line habitat as breeding habitat.

5.4.2 Vertebrate species of conservation significance possibly occurring

Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*) (Priority 3 listed by DPaW)

Like many critical weight range (CWR) mammals the Spectacled Hare-wallaby has suffered widespread range reduction and population declines on the mainland. The species is also known from the bioregion at Barrow Island, where it is abundant, however, the mainland subspecies is an inhabitant of northern Australia and is rare in the Pilbara, with scattered populations. Inappropriate fire regimes and the impacts of feral predators have impacted this species significantly, particularly in southern parts of its distribution. Burbidge and Johnson (2008) suggest that frequent broadscale fire prevents the development of spinifex hummocks large enough to provide shelter for the species.

Although the species has previously been recorded within 30 km of the study area (Figure 4.6) the most recent record is from 1996, with no records from recent comprehensive surveys, and is likely to be indicative of the ongoing decline in numbers in the Pilbara. Past and present fire management is likely to be contributing to declines. Although spinifex grasslands associated with Stony Plains habitat is found over the survey area, it is unlikely that the species persists.

Northern Quoll (*Dasyurus hallucatus*) (Endangered under *EPBC Act* and *WC Act*)

The Northern Quoll once occurred continuously across the north of Australia but now occurs in six separate land units of which the Pilbara is one (DSEWPaC 2011). The Pilbara is regarded as the stronghold population for the species given that the Cane Toad is not expected to make its way across the desert into parts of the Pilbara (Woinarski *et al.* 2014). Preferred habitat is rocky escarpments, but it also inhabits riverine habitats (Woinarski *et al.* 2014). Rocky habitats with rock crevices and caves support higher densities of Northern Quolls (van Dyck and Strahan 2008; Woinarski *et al.* 2014).

Ninety-seven records of the Northern Quoll have been made within 25 km of the study area (Figure 4.6). All vegetated habitats can be utilised for foraging and dispersal, and DSEWPaC (2011) recognise foraging and dispersal habitat as any land comprising predominantly native vegetation within 2 km of denning and/or shelter habitat, or any recent quoll records. The Northern Quoll was not recorded during the survey, with the closest record approximately 16 km away. Furthermore, no denning (or foraging) habitat occurs, and surveys by 360 Environmental (2016a) and MMWC Environmental

(2016) found no evidence of the species immediately to the south and it is unlikely that the Northern Quoll occurs in the study area.

Brush-tailed Mulgara (*Dasycercus blythi*) (Priority 4 listed by DPaW)

The mulgara inhabits sandplains dominated by *Triodia* spp., where it typically burrows between low sand dunes. The species has defined home ranges, which overlap extensively including between the sexes. Home ranges and burrows encompass both mature spinifex and open regrowth (Koertner *et al.* 2007).

Fourteen records of the Brush-tailed Mulgara have been made within 25 km of the study area (Figure 4.6). No signs of the Brush-tailed Mulgara were recorded during the survey, or by 360 Environmental (2016a), Natural Area (2016) and MMWC Environmental (2016). The species is infrequently recorded in part due to boom-bust cycles, contracting to core habitat areas in lean times, and expanding rapidly after favourable conditions prevail (Masters 2003). Substrates of the Stony Plains habitat over the study area are unlikely to support the burrowing Mulgara, few records occur within the immediate vicinity and subsequent predation by feral predators, is likely to restrict the presence of this species.

Greater Bilby (*Macrotis lagotis*) (Vulnerable under *EPBC Act* and *WC Act*)

Bilbies occur in a variety of habitats, usually on landforms with level to low slope topography with light to medium soils, and typically sandy, for burrow excavation. The Bilby suffered a sudden and widespread population crash in the early 20th Century and is now confined to the driest and least fertile parts of its former range and its distribution is negatively correlated with that of the Red Fox.

However, the Greater Bilby is known from the bioregion and twelve records exist within 25 km of the study area, with the closest being an old record (1979) roughly 5km to the east (Figure 4.6). Although difficult to trap, evidence of this species is distinctive due to extensive burrowing, and obvious diggings over foraging areas and no evidence was obtained during this survey; nor by Natural Area (2016), 360 Environmental (2016a) or MMWC Environmental (2016). An inhabitant of spinifex plains, the Stony Plains habitat within the study area offers potential habitat for this species. However, lack of suitable burrowing substrates and pressure from feral predators is likely to have severely diminished habitat quality for this rare species.

Ghost Bat *(Macroderma gigas)* (Vulnerable under EPBC Act and WC Act)

The species is known from a wide range of habitats from northern Australia; from the arid Pilbara to tropical rainforests in Queensland (Churchill 1998). The Pilbara population is probably disjunct from the wider distribution due to the uninhabitable arid zone to the north and east. The semi-desert Pilbara population has specific roosting requirements associated with temperature and humidity. The causes for its range reduction are unclear but its distribution is limited by the availability of suitable caves and abandoned mines used as roost sites.

The Ghost Bat is known to occur in the region with a very widespread but patchy distribution (Armstrong and Anstee 2000) and 12 records occur within 25 km of the study area (Figure 4.6). Although roost habitat is specific, the Ghost Bat can forage over a wide range of habitat within approximately two kilometres from roost caves (Churchill 2008). The Ghost Bat does not only forage using echolocation during flight, but also uses passive sit and wait hunting technique using eyesight to scan for prey from a feeding roost up to three metres above ground including rocky overhangs and branches of trees (Churchill 2008). Because Ghost Bats can navigate visually without recourse to calling (Armstrong and Anstee 2000) calls recorded from echolocation units can only indicate their presence or absence in an area. Additionally, Ghost Bats may depart important day roosts on dusk and not return until dawn (Armstrong and Anstee 2000), meaning that activity levels quantified by

recorded calls do not necessarily have any relationship with the significance of the cave to the species.

The Ghost Bat was not recorded during this survey, nor during the Natural Areas (2016), 360 Environmental (2015; 2016a), or the MMWC Environmental (2016). No roosts are known to occur within the study area; however, due to regional records and its large foraging range, it is possible that the Ghost Bat may occasionally forage within the study area along Drainage Line habitat intermittently.

Peregrine Falcon (*Falco peregrinus*) (Specially protected under the WC Act)

The Peregrine Falcon is widespread in Australia, but requires specific nesting sites Pilbara (Johnstone and Storr 1998). It does not build a nest and requires cliffs, rocky outcrops, or large tree Hollows (Johnstone and Storr 1998). The Peregrine Falcon prefers to be near water, and in the arid zone breeding is restricted to rocky ranges and feed almost entirely on birds, especially ducks, parrots and pigeons (Olsen and Fuentes 2008).

There are two records from within 25 km of the study area (Figure 4.6) although the Peregrine Falcon was not recorded during this study, nor by 360 Environmental (2016a) or MMWC Environmental (2016). The study area lacks suitable nesting habitat such as breakaways, cliffs or river habitat however due to its widespread distribution the species may utilise all habitats of the study area as a part of a larger foraging area.

Grey Falcon (*Falco hypoleucos*) (Vulnerable under WC Act)

This Grey Falcon is a poorly-known endemic of inland Australia that has a very broad but scattered distribution that includes the Pilbara bioregion (Garnett *et al.* 2011). The species is a resident or nomadic visitor to inland parts and occurs in lightly wooded riverine plains. The species often nests in eucalypts along watercourses and has been recorded from both River Red Gum (*Eucalyptus camaldulensis*) and Coolibah (*Eucalyptus coolabah*) (Garnett *et al.* 2011).

Three records have been made within 25 km of the study area (Figure 4.6) the latest of which was in 2015. Few tall trees suitable for nesting are present but due to its widespread distribution the Grey Falcon may overfly the area from time to time.

Fork-tailed Swift (*Apus pacificus*) (Protected under international agreements)

The Fork-tailed Swift is a migratory, almost exclusively aerial species that, in its non-breeding area in Australia, is independent of terrestrial habitats. The Fork-tailed Swift arrives in Australia from its breeding areas in Siberia in October and leaves by the end of April (Higgins 1999). They forage along the edge of low pressure systems which help lift insect prey and assists in flight.

The Fork-tailed Swift has been recorded fifteen times within a 25km radius of the study area (Figure 4.6). The Fork-tailed Swift therefore has the potential to overfly the entire study area without specifically utilising any particular habitat present.

5.4.3 Other vertebrate species of interest

Pilbara Olive Python (*Liasis olivaceus barroni*) (Vulnerable under EPBC Act and WC Act)

The Pilbara Olive Python (*Liasis olivaceus barroni*) is listed as Vulnerable under both the EPBC Act and the WC Act. It's preferred habitat is rocky gorges with permanent water, or along well-vegetated water-courses, although it has been observed in locations distant from water (Bush and Maryan 2011). Olive Pythons occur throughout that Pilbara and can also be found in habitats including granite outcrops, elevated mesas and spinifex plains on stony ground where it shelters in caves, crevices and beneath large boulders (Bush and Maryan 2011).

Nine records have been made within a 25 km of the study area (Figure 4.6) and no individuals were captured during recent surveys by Natural Area (2016), 360 Environmental (2016a) or MMWC Environmental (2016).As no rocky outcrops, gorges or permanent water are available within the study area, it is unlikely that Pilbara Olive Pythons will occur.

5.5 FLORA SURVEY LIMITATIONS AND CONSTRAINTS

An assessment of survey-specific issues and limitations (EPA 2016c) is detailed in Table 5.4.

Table 5.4 – Flora and vegetation survey limitations

Constraint	Impact	Comment
Availability of contextual information at a regional and local scale	Nil	Broad-scale vegetation, soil, and geology information was available for the study area, in addition to flora database records and conservation significant vegetation community records. This information is adequate to provide appropriate contextual information for the current survey.
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed	Nil	The Senior Botanist undertaking the field work and specimen identification for the survey has conducted numerous botanical surveys in the Pilbara bioregion.
Proportion of plant species recorded and/or collected, any identification issues	Nil	All species encountered within the study area were recorded. 122 taxa were recorded within a 345-ha area, which is expected to be a large proportion of plant species present. Only two taxa could not be identified to species level due to a lack of required flowering or fruiting material.
Was the appropriate area fully surveyed (effort and extent)	Nil	The level of survey effort was sufficient for a reconnaissance survey.
Access restrictions within the survey area	Nil	All parts of the study area were accessible by walking from existing vehicle tracks.
Survey timing, rainfall, season of survey	Nil	The survey was conducted during adequate seasonal conditions for flora and vegetation surveys in the Pilbara.
Disturbance that may have affected the results of survey such as fire, flood or clearing	Nil	There were no natural or human interventions that constrained the survey of the study area.

5.6 FAUNA SURVEY LIMITATIONS AND CONSTRAINTS

According to Technical Guidance: Terrestrial Fauna Surveys (EPA 2016e), terrestrial fauna surveys may be limited by several aspects. An assessment of these aspects with regard to this study is detailed in Table 5.5.

Table 5.5 – Fauna survey limitations

Aspect	Constraint	Comment
Competency/experience of the consultant carrying out the survey.	Nil	The Principal Zoologist undertaking the fauna survey has more than 10 years of experience in conducting terrestrial vertebrate fauna surveys in Western Australia, including in the Pilbara
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	Nil	A detailed fauna survey was not a vital component for this level of assessment (Level 1 Survey). The scope was well defined. Fauna and their habitats were surveyed using standardised and well-established techniques. Relevant databases and previous studies surrounding the study area were reviewed.
Proportion of fauna identified, recorded and/or collected.	Low	A detailed fauna survey was not a vital component for this level of assessment (Level 1 Survey). A comprehensive desktop study adequately gathered background information on the study area. A reconnaissance survey verified the desktop results and characterised habitats and terrestrial fauna likely to be present to enable an identification of potential impacts.
Sources of information (previously available information as distinct from new data).	Nil	The study area is located in a well-surveyed region with comprehensive survey information available from adjacent areas. Database records, including conservation significant species, were available for the area and considered adequate to provide appropriate contextual information for the study.
The proportion of the task achieved and further work which might be needed.	Nil	Planned survey works were conducted and completed according to an agreed scope.
Timing/weather/season/cycle.	Nil	The survey was conducted following higher than average rainfall.
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	Nil	There were no natural or human interventions that constrained the survey of the study area.
Intensity (in retrospect was the intensity adequate).	Low	Given the access to available information from areas immediately adjacent and in comparable habitats the survey intensity was considered adequate and is appropriate for a Level 1 fauna assessment.
Completeness (e.g. was relevant area fully surveyed).	Nil	The Level 1 survey was considered complete. Database searches and literature reviews were comprehensive and a large proportion of the Study Area was sampled on foot.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Nil	Resources were adequate to carry out the survey and survey participants were competent in the identification of species and likelihood of occurrence. Database searches and literature reviews were used to prepare for the survey and used for the confirmation of any species.
Remoteness and/or access problems.	Nil	The study area was easily accessible by vehicle and on foot.
Availability of contextual (e.g. biogeographic) information on the region.	Nil	The data available was adequate for the level of survey work undertaken during this assessment.
Efficacy of sampling methods (i.e. any groups not sampled by survey methods).	Nil	A detailed fauna survey was not a vital component for this level of assessment (Level 1 Survey). A comprehensive desktop study adequately gathered background information on the study area. A reconnaissance survey verified the desktop results and characterised habitats

6 DISCUSSION

6.1 FLORA

6.1.1 Floristic Diversity

A total of 122 sub-generic vascular plant taxa (including species, infraspecific taxa, and phrase names) representing 71 genera and 27 families were recorded from the study area. Of these, two were Priority listed flora and three were introduced. The most diverse families were the Poaceae (31 taxa), Fabaceae (25 taxa), Malvaceae (12 taxa), Amaranthaceae (10 taxa), and Goodeniaceae (six taxa), while the most diverse genera were *Acacia* (nine taxa), *Ptilotus* (eight taxa), *Triodia* (six taxa), *Eriachne* (four taxa), and *Euphorbia* (four taxa). The overall floristic composition of the study area is typical of the broader Pilbara region, and for the landforms present.

6.1.2 Introduced species

Three introduced species (*Cenchrus ciliaris*, *Cenchrus setiger*, and *Echinochloa colona*) were recorded within the study area. *Cenchrus ciliaris* and *C. setiger* were primarily associated with the minor creek line and adjacent floodplains, while *E. colona* was recorded in low abundance from gilgai. These species are listed as 'Permitted' on the Western Australian Organism List (DAFWA 2016), and are not Weeds of National Significance. Each species has a 'High' risk rating and 'Rapid' invasiveness rating according to the Environmental Weed Strategy (CALM 1999).

6.1.3 Significant Species

Two State listed Priority Flora species were recorded within the study area: *Euphorbia clementii* (Priority 3) and *Triodia chichesterensis* (Priority 3).

Euphorbia clementii (Euphorbiaceae) is a multi-stemmed herb that is relatively widespread in the north-eastern Pilbara region, from approximately 150 km south of Port Hedland to near Pardoo. Approximately 250 individuals were recorded within the study area, where it was found almost exclusively on vehicle tracks and windrows. It was also observed growing extensively along other disturbed roadsides near the study area. Observations made during this and other surveys in surrounding areas suggest that this species is a disturbance opportunist and can proliferate after fire. Based on current DBCA records, this species is well represented outside of the study area.

Triodia chichesterensis (Poaceae) is a hard-leaved spinifex grass restricted the central Chichester IBRA subregion. It was recorded from the eastern border of the study area where it formed a dominant component of the vegetation community present on stony quartzite plains. Based on current DBCA records, this species is well represented outside of the study area. It was also potentially recorded by MMWC Environmental (2016) immediately north of the study area, under the name *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835). This phrase name taxon is now formally described as *Triodia vanleeuwenii*, which is, based on current knowledge, restricted to the eastern Hamersley Range, approx. 150 km south of the study area, but is morphologically similar to *T. chichesterensis*. It is therefore possible that specimens identified by MMWC Environmental (2016) as *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) belong to *T. chichesterensis*, but this cannot be verified without viewing specimens.

6.2 VEGETATION

Six vegetation units were described and mapped within the study area based on data collected from 27 sites in addition to other observations made during the field survey. These units are consistent with vegetation described for the Satirist land system (Van Vreeswyk *et al.* 2004a). The units described only broadly correspond to those mapped by Beard (1975), in which *Grevillea pyramidalis*,

Hakea lorea, and *Senna* spp. tall sparse shrubland (unit 93) is mapped over the vast majority of the study area, although this mapping was done at a much broader scale.

Vegetation units W1, W2, S1, and S3 broadly correspond to vegetation types described and mapped for stony plains, drainage lines and creek lines by Natural Area (2016) immediately to the east of the study area. There were no vegetation types identified by Natural Area (2016) that corresponded to units S2 and S4.

MMWC Environmental (2016) described and mapped vegetation immediately to the north of the study area. Vegetation type 2a (scattered low trees of *Corymbia hamersleyana* over scattered tall shrubs of *A. inaequilatera* over open hummock grassland of *T*. sp. Shovelanna Hill and *T. wiseana* occurring on stony plains) corresponds broadly to vegetation unit S1 and possibly to unit S4 (see note on *Triodia* sp. Shovelanna Hill, above). Vegetation type 6c (scattered low trees of *Corymbia hamersleyana* over tall shrubland of *A. tumida* var. *pilbarensis* and *Petalostylis labicheoides* over open hummock grassland of *T. epactia* and *T. angusta* occurring along minor drainage lines) corresponds to vegetation unit S3. Vegetation type 5b (low open woodland of *Eucalyptus victrix* and *Corymbia hamersleyana* occurring in creek lines) corresponds to vegetation units W1 and W2. These vegetation units are therefore not expected to be restricted to the M45/1260 study area.

None of the vegetation units within the study area correspond to any TEC or PEC; however, vegetation unit S4 may be considered locally significant as it supports the Priority 3 species *Triodia chichesterensis*. Vegetation unit W1 supports *Eucalyptus victrix*, which is a facultative phreatophyte, that is, it is potentially groundwater dependant in situations where surface water is unavailable.

6.3 FAUNA AND FAUNA HABITATS

The composition and current status of the vertebrate fauna and habitats of the Pilbara Bioregion is relatively well known due to the large number of recent broad-scale systematic surveys including Gibson and McKenzie (2009), McKenzie and Bullen (2009a), Burbidge *et al.* (2010), Doughty *et al.* (2011), and Johnstone *et al.* (2013). In addition, the immediate locality has been subject to a number of recent relevant fauna and fauna habitat surveys in the region, including the adjacent Pilgangoora Project, along with surveys by Bamford (2009), Outback Ecology (2009), Outback Ecology (2011), Woodman (2012), *ecologia* (2012a), *ecologia* (2012b), 360 Environmental (2015), Bennelongia (2016a), Bennelongia (2016b), 360 Environmental (2016b), 360 Environmental (2016a), MMWC Environmental (2016) and Natural Area (2016).

Assessed information has contributed to the Pilbara increasingly being viewed as a centre for biodiversity (e.g. McKenzie *et al.* (2003), and is recognised as one of the richest bioregions for reptiles (Doughty *et al.* 2011). The 'Hamersley-Pilbara' region has been listed by the Federal Minister for Environment as one of 15 biodiversity hotspots in Australia, providing habitat for a number of threatened, endemic and fire-sensitive species (DoEE 2017), and the Hamersley and Chichester Ranges are considered refugia (Morton *et al.* 1995).

Since European settlement, 12 mammal species have become extinct in the region, and two species now only persist on coastal islands (Burbidge *et al.* 2010). The major threatening processes affecting biodiversity over the study area are altered fire regimes, grazing by introduced herbivores, impacts of introduced predators and weed invasion (McKenzie *et al.* 2003). It is impossible to separate the severity and scope of impacts associated with these threats as all processes are intimately connected. For example, over-grazing can facilitate the introduction and spread of weeds. Frequent hot fire leads to reduced heterogeneity in the landscape, including less shelter, leading to greater impacts on ground fauna, particularly critical-weight range mammals, from introduced predators such as the fox and feral cat (Burbidge and McKenzie 1989). Local fire refuges, therefore, are critical for the maintenance of local biodiversity.

Fauna that are regarded as threatened or are associated with habitats that are site or type specific and possess high ecological value, are of significance. At the national level DoE (2013) defines habitat

critical to the survival of a species "as areas that are necessary for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species; to maintain genetic diversity; or for the reintroduction of populations or the recovery of the species. At the state level EPA (2016b) suggest that habitat may also be significant if it provides areas important to the life history of a significant species (such as breeding, feeding, roosting, or aggregation areas), or where habitats are unique or isolated in the landscape" (EPA 2016b).

All the habitats identified within the study area are well represented elsewhere in the Bioregion, as well as within conservation reserves, and the study area does not provide habitat important to the life history of any conservation significant species. None of the habitats present, therefore, are considered of national, state or regional significance. From a local perspective Minor Drainage Lines generally support greater species richness and abundances than other habitats. Although these habitats can also be affected by detrimental frequent burning, their linear configuration and more mesic characteristics facilitate dual roles as both fire refuge, and routes for immigration and emigration.

Three listed vertebrate species of conservation significance are likely to occur over the study area. No maternity caves or roosting caves for the Pilbara Leaf-nosed Bat or Ghost Bat were recorded; however, the former is likely to forage and disperse along drainage line habitat from a known roost site (East Turner River Roost; PM30) to the northeast of the study area. The Western Pebble-mound Mouse is likely to occur in Stony Plains habitat that provides pebbles of a suitable size for the construction of burrows, and the Rainbow Bee-eater would occur in all habitats over the study area and may utilise banks along Minor Drainage Line habitat for breeding.

The Northern Quoll was not recorded during the survey with the closest record approximately 16 km from the study area. Furthermore, no denning or suitable foraging habitat occurs and comprehensive surveys by 360 Environmental (2016a) and MMWC Environmental (2016) found no evidence of the species immediately to the northeast, and as a consequence it is unlikely that the Northern Quoll occurs in the study area.

Stony Plains within the study area are unlikely to support the burrowing habitat for the Greater Bilby and the Brush-tailed Mulgara with few records occurring, a lack of sandy plain habitat and the subsequent predation by feral predators likely to restrict the presence of these species in the area.

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8 APPENDICES

APPENDIX A DEFINITIONS

Threatened (WC Act) and Priority flora Categories

Code	Definition
T	**Threatened flora – (Declared Rare Flora – Extant)** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*).
X	**Presumed Extinct Flora (Declared Rare Flora - Extinct)** Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such Schedule 2 under the *Wildlife Conservation Act 1950*).
P1	**Priority One – Poorly Known Species** Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	**Priority Two – Poorly Known Species** Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	**Priority Three – Poorly Known Species** Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4	**Priority Four – Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
P5	**Priority Five - Conservation Dependent species** Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Threatened flora (EPBC Act) Categories

Code	Definition
Ex	**Extinct** Taxa which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, the species is the focus of a specific conservation programme, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Definition of codes for Threatened Ecological Communities

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Definition of codes for Priority Ecological Communities

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Ecological communities that have been removed from the list of threatened communities during the past five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

BAM Act Definitions (Declared Pests)

Legal status	Definition
Declared Pest, Prohibited - s12	Prohibited organisms are declared pests by virtue of section 22(1), and may only be imported and kept subject to permits. Permit conditions applicable to some species may only be appropriate or available to research organisations or similarly secure institutions.
Declared Pest - s22(2)	Declared pests must satisfy any applicable import requirements when imported, and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia.
Permitted - s11	Permitted organisms must satisfy any applicable import requirements when imported. They may be subject to an import permit if they are potential carriers of high-risk organisms.
Permitted, Requires Permit - r73	Regulation 73 permitted organisms may only be imported subject to an import permit. These organisms may be subject to restriction under legislation other than the Biosecurity and Agriculture Management Act 2007. Permit conditions applicable to some species may only be appropriate or available to research organisations or similarly secure institutions.
Unlisted - s14	If you are considering importing an unlisted organism/s you will need to submit the name/s for assessment, as unlisted organisms are automatically prohibited entry into WA.
Control categories	Definition
C1 Exclusion	Organisms which should be excluded from part or all of Western Australia.
C2 Eradication	Organisms which should be eradicated from part or all of Western Australia.
C3 Management	Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism.
Unassigned	Unassigned: Declared pests that are recognised as having a harmful impact under certain circumstances, where their subsequent control requirements are determined by a Plan or other legislative arrangements under the Act.

Categorisation of Environmental Weeds

Criteria	**Description**
Invasiveness	Ability to invade bushland in good to excellent condition or ability to invade waterways.
Distribution	Wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world.
Environmental impacts	Ability to change the structure, composition and function of ecosystems. In particular an ability to form single-species stands.
Category	**Scoring System**
High	A species which scores yes to all three of the above criteria. A rating of high indicates a species that should be prioritised for control and/or research.
Moderate	A species which scores yes for two of the above criteria. A rating of moderate indicates a species which should be monitored. Control or research should be directed to it if funds are available.
Mild	A species which scores yes to one of the criteria. A mild rating indicates monitoring or control if appropriate.
Low	A species which does not score yes for any of the criteria. A low rating indicates a low requirement for monitoring.

Threatened (WC Act) Fauna Categories

Category	Code	Definition	Schedule
Critically Endangered	CR	Threatened species considered to be facing an extremely high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.	**Schedule 1** Fauna that is rare or is likely to become extinct as critically endangered fauna
Endangered	EN	Threatened species considered to be facing a very high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.	**Schedule 2** Fauna that is rare or is likely to become extinct as endangered fauna
Vulnerable	VU	Threatened species considered to be facing a high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.	**Schedule 3** Fauna that is rare or is likely to become extinct as vulnerable fauna
Presumed Extinct	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.	**Schedule 4** Fauna presumed to be extinct
Migratory	IA	Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice.	**Schedule 5** Migratory birds protected under an international agreement
Conservation Dependent	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice.	**Schedule 6** Fauna that is of special conservation need as conservation dependent fauna
Special Protection	OS	Fauna otherwise in need of special protection to ensure their conservation. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.	**Schedule 7** Other specially protected fauna

Fauna (EPBC Act) Categories

Category	Code	Definition
Extinct	Ex	Fauna not definitely located in the wild during the past 50 years
Extinct in the Wild	EW	Fauna which is known only to survive in captivity
Critically Endangered	CR	Fauna that is considered to be facing an extremely high risk of extinction in the wild in the immediate future
Endangered	EN	Fauna that is considered to be facing a very high risk of extinction in the wild in the near future
Vulnerable	VU	Fauna that is considered to be facing a high risk of extinction in the wild in the medium-term future
Conservation Dependent	CD	Fauna whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
Migratory	IA	Fauna that migrates to, over and within Australia and its external territories.

Definition of codes for Priority Fauna

Code	Definition
P1: Priority One	**Poorly-known species** Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
P2: Priority Two	**Poorly-known species** Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
P3: Priority Three	**Poorly-known species** Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
P4: Priority Four	**Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Definition of Short-range Endemic Invertebrates (SREs) (Western Australian Museum)

Confirmed SREs	Species with a known range smaller than 10,000 km^2. Taxonomy is well known and the group is well represented in collections and/or has been comprehensively sampled
Potential SREs	Species that belong to a group where there are gaps in our knowledge of the taxon, either because the group is not well represented in collections, taxonomic knowledge is incomplete, or the distribution is imperfectly understood because sampling has been patchy.
Widespread (not SREs)	Species that have a known distribution range larger than 10,000 km^2. The taxonomy is well known and the group is well represented in collections and/or has been comprehensively sampled.

APPENDIX B VASCULAR FLORA RECORDS. NATUREMAP (40 KM BUFFER)

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 12/06/2018

Kingdom	Plantae
Current Names Only	Yes
Core Datasets Only	Yes
Vouchered Status	Vouchered
Method	'By Circle'
Centre	118° 52' 29" E,21° 04' 29" S
Buffer	40km

Area (ha)		502569.66
Taxa:	Naturalised	8
	Native	293
Endemics:		1
Families:		51
Genera:		133
Conservation Status:	-	282
	1	1
	3	13
	T	1
	4	3
	2	1
MS Status:	-	292
	PN	9
Rank:	-	260
	subsp.	22
	var.	19

Top Ten Families

		Species	Records
1.	Fabaceae	58	112
2.	Poaceae	49	91
3.	Malvaceae	25	50
4.	Cyperaceae	19	39
5.	Amaranthaceae	17	28
6.	Asteraceae	11	16
7.	Goodeniaceae	11	17
8.	Boraginaceae	10	48
9.	Aizoaceae	7	9
10.	Solanaceae	7	18

Top Ten Genera

		Species	Records
1.	*Acacia*	18	50
2.	*Tephrosia*	12	23
3.	*Ptilotus*	10	19
4.	*Triodia*	10	28
5.	*Cyperus*	9	15
6.	*Triumfetta*	8	24
7.	*Heliotropium*	7	43
8.	*Trianthema*	7	9
9.	*Eragrostis*	7	13
10.	*Solanum*	6	13

[1] Endemic To Query Area

Name ID	Species	Conservation Status
37720	*Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)*	T

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 12/06/2018

Kingdom Plantae
Current Names Only Yes
Core Datasets Only Yes
Vouchered Status Vouchered
Method 'By Circle'
Centre 118° 52' 29" E,21° 04' 29" S
Buffer 40km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	4895	*Abutilon lepidum*			
2.	42920	*Abutilon sp. Dioicum (A.A. Mitchell PRP 1618)*			
3.	3198	*Acacia acradenia*			
4.	3209	*Acacia ampliceps*			
5.	3214	*Acacia ancistrocarpa (Fitzroy Wattle)*			
6.	3223	*Acacia arida*			
7.	13502	*Acacia coriacea subsp. pendens*			
8.	12673	*Acacia glaucocaesia*			
9.	3370	*Acacia hilliana*			
10.	3377	*Acacia inaequilatera (Baderi)*			
11.	23523	*Acacia leeuweniana*		P1	
12.	15289	*Acacia levata*		P3	
13.	3434	*Acacia maitlandii (Maitland's Wattle)*			
14.	3471	*Acacia orthocarpa (Needleleaf Wattle)*			
15.	29015	*Acacia pyrifolia var. pyrifolia*			
16.	15215	*Acacia retivenea subsp. clandestina*			
17.	13078	*Acacia sclerosperma subsp. sclerosperma*			
18.	3553	*Acacia spondylophylla*			
19.	19456	*Acacia stellaticeps*			
20.	20319	*Acacia tumida var. pilbarensis*			
21.	17422	*Adriana tomentosa var. tomentosa*			
22.	2646	*Aerva javanica (Kapok Bush)*	Y		
23.	2652	*Alternanthera nodiflora (Common Joyweed)*			
24.	2663	*Amaranthus interruptus (Native Amaranth)*			
25.	2666	*Amaranthus mitchellii (Boggabri Weed)*			
26.	20018	*Amaranthus undulatus*			
27.	5278	*Ammannia multiflora*			
28.	204	*Aristida burbidgeae*			
29.	12063	*Aristida holathera var. holathera*			
30.	5183	*Bergia ammannioides*			
31.	2770	*Boerhavia coccinea (Tar Vine, Wituka)*			
32.	2772	*Boerhavia gardneri*			
33.	6603	*Bonamia alatisemina*			
34.	11167	*Bonamia erecta*			
35.	44782	*Bonamia pilbarensis*			
36.	750	*Bulbostylis barbata*			
37.	751	*Bulbostylis burbidgeae*		P4	
38.	18073	*Byblis filifolia*			
39.	10852	*Cajanus acutifolius*			
40.	11055	*Cajanus cinereus*			
41.	40825	*Calandrinia pentavalvis*			
42.	2870	*Calandrinia stagnensis*			
43.	2872	*Calandrinia tepperiana*			
44.	14090	*Calocephalus beardii*			
45.	6582	*Calotropis procera (Calotrope)*	Y		
46.	48291	*Capparis spinosa subsp. nummularia*			
47.	258	*Cenchrus ciliaris (Buffel Grass)*	Y		
48.	7919	*Centipeda minima (Spreading Sneezewood, Kanjirralaa, Inteng-inteng, Karengkal, Kata-palkalpa, Munyu-parnti-parnti)*			
49.	32	*Cheilanthes brownii*			
50.	273	*Chrysopogon fallax (Golden Beard Grass)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
51.	29101	*Cleome uncifera subsp. uncifera*			
52.	2988	*Cleome viscosa (Tickweed, Tjinduwadhu)*			
53.	2778	*Codonocarpus cotinifolius (Native Poplar, Kundurangu)*			
54.	13659	*Corchorus laniflorus*			
55.	4862	*Corchorus parviflorus*			
56.	19125	*Corymbia dichromophloia*			
57.	17084	*Corymbia zygophylla*			
58.	1286	*Corynotheca pungens*			
59.	3774	*Crotalaria cunninghamii (Green Birdflower, Bilbun)*			
60.	20179	*Crotalaria medicaginea var. neglecta*			
61.	3785	*Crotalaria novae-hollandiae (New Holland Rattlepod)*			
62.	7371	*Cucumis melo (Ulcardo Melon)*			
63.	17119	*Cullen leucochaites*			
64.	17116	*Cullen martinii*			
65.	15714	*Cullen stipulaceum*			
66.	33077	*Cylindropuntia imbricata*	Y		
67.	279	*Cymbopogon ambiguus (Scentgrass)*			
68.	6583	*Cynanchum carnosum*			
69.	48280	*Cynanchum viminale subsp. australe*			
70.	46558	*Cynodon convergens*			
71.	46555	*Cynodon prostratus*			
72.	12801	*Cyperus blakeanus*			
73.	13657	*Cyperus castaneus var. brevimucronatus*			
74.	784	*Cyperus conicus*			
75.	12811	*Cyperus cunninghamii subsp. cunninghamii*			
76.	12808	*Cyperus hesperius*			
77.	798	*Cyperus iria*			
78.	807	*Cyperus pulchellus*			
79.	809	*Cyperus rigidellus*			
80.	814	*Cyperus squarrosus*			
81.	290	*Dactyloctenium radulans (Button Grass)*			
82.	7424	*Dampiera candicans*			
83.	7317	*Dentella asperata*			
84.	3853	*Desmodium filiforme*			
85.	48378	*Diplachne fusca subsp. fusca*			
86.	48390	*Dolichandrone occidentalis*			
87.	3093	*Drosera burmanni (Tropical Sundew)*			
88.	823	*Eleocharis atropurpurea*			
89.	357	*Enneapogon caerulescens (Limestone Grass)*			
90.	360	*Enneapogon lindleyanus (Wiry Nineawn, Purple-head Nineawn)*			
91.	12749	*Enneapogon purpurascens (Purple Nineawn)*			
92.	16730	*Eragrostis crateriformis*		P3	
93.	375	*Eragrostis cumingii (Cuming's Love Grass)*			
94.	378	*Eragrostis dielsii (Mallee Lovegrass)*			
95.	380	*Eragrostis eriopoda (Woollybutt Grass, Wangurnu)*			
96.	15733	*Eragrostis fallax*			
97.	389	*Eragrostis minor (Smaller Stinkgrass)*	Y		
98.	395	*Eragrostis speciosa (Handsome Lovegrass)*			
99.	15052	*Eremophila forrestii subsp. forrestii*			
100.	17169	*Eremophila latrobei subsp. glabra*			
101.	7234	*Eremophila longifolia (Berrigan, Tulypurpa)*			
102.	400	*Eriachne aristidea*			
103.	403	*Eriachne benthamii (Swamp Wanderrie)*			
104.	407	*Eriachne festucacea (Plains Wandarrie Grass)*			
105.	412	*Eriachne melicacea*			
106.	414	*Eriachne obtusa (Northern Wandarrie Grass)*			
107.	14377	*Erymophyllum ramosum subsp. ramosum*			
108.	5698	*Eucalyptus leucophloia (Snappy Gum, Migum)*			
109.	35303	*Euphorbia australis var. subtomentosa*			
110.	9048	*Euphorbia careyi*			
111.	4622	*Euphorbia clementii*		P2	
112.	12097	*Euphorbia tannensis subsp. eremophila (Desert Spurge)*			
113.	11200	*Evolvulus alsinoides var. villosicalyx*			
114.	31578	*Ficus aculeata var. indecora (Ranji)*			
115.	19648	*Ficus brachypoda*			
116.	853	*Fimbristylis elegans*			
117.	862	*Fimbristylis microcarya*			
118.	882	*Fimbristylis sieberiana*		P3	
119.	12159	*Fimbristylis simulans*			
120.	4654	*Flueggea virosa*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
121.	896	*Fuirena ciliaris*			
122.	18257	*Gomphrena leptoclada subsp. leptoclada*			
123.	17894	*Gomphrena leptophylla*		P3	
124.	6151	*Gonocarpus ephemerus*			
125.	7521	*Goodenia lamprosperma*			
126.	7526	*Goodenia microptera*			
127.	12552	*Goodenia muelleriana*			
128.	7530	*Goodenia nuda*		P4	
129.	10982	*Goodenia stobbsiana*			
130.	4910	*Gossypium australe (Native Cotton)*			
131.	4918	*Gossypium robinsonii (Wild Cotton)*			
132.	12832	*Gymnanthera cunninghamii*		P3	
133.	2789	*Gyrostemon tepperi*			
134.	30258	*Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)*			
135.	17301	*Heliotropium chrysocarpum*			
136.	6705	*Heliotropium crispatum*			
137.	6706	*Heliotropium cunninghamii*			
138.	10891	*Heliotropium muticum*		P3	
139.	17309	*Heliotropium pachyphyllum*			
140.	17313	*Heliotropium skeleton*			
141.	11057	*Heliotropium vestitum*			
142.	443	*Heteropogon contortus (Bunch Speargrass)*			
143.	29316	*Hibiscus austrinus*			
144.	29317	*Hibiscus austrinus var. austrinus*			
145.	4924	*Hibiscus burtonii*			
146.	4925	*Hibiscus coatesii*			
147.	4930	*Hibiscus goldsworthii*			
148.	11651	*Hibiscus sturtii var. campylochlamys*			
149.	5215	*Hybanthus aurantiacus*			
150.	3978	*Indigofera hirsuta (Hairy Indigo)*			
151.	3980	*Indigofera linifolia*			
152.	3981	*Indigofera linnaei (Birdsville Indigo)*			
153.	3982	*Indigofera monophylla*			
154.	3985	*Indigofera rugosa*			
155.	31035	*Indigofera trita subsp. trita*			
156.	6623	*Ipomoea coptica*			
157.	6633	*Ipomoea muelleri (Poison Morning Glory, Yumbu)*			
158.	3989	*Isotropis atropurpurea (Poison Sage)*			
159.	12059	*Jasminum didymum subsp. lineare (Desert Jasmine)*			
160.	3035	*Lepidium pedicellosum*			
161.	3037	*Lepidium phlebopetalum (Veined Peppercress)*			
162.	3038	*Lepidium pholidogynum*			
163.	952	*Lipocarpha microcephala*			
164.	37480	*Lobelia arnhemiaca*			
165.	4658	*Mallotus nesophilus*			
166.	5933	*Melaleuca linophylla*			
167.	31374	*Microstachys chamaelea*			
168.	6519	*Mitrasacme connata*			
169.	1167	*Murdannia graminea (Baniyu)*			
170.	6980	*Nicotiana umbratica*		P3	
171.	38422	*Notoleptopus decaisnei var. decaisnei*			
172.	31799	*Opuntia elata*	Y		
173.	5227	*Opuntia stricta (Common Prickly Pear)*	Y		
174.	4518	*Owenia reticulata (Native Walnut, Bandal)*			
175.	503	*Panicum decompositum (Native Millet, Kaltu-kaltu)*			
176.	515	*Paraneurachne muelleri (Northern Mulga Grass)*			
177.	519	*Paspalidium constrictum (Knottybutt Grass)*			
178.	523	*Paspalidium rarum (Rare Paspalidium)*			
179.	525	*Paspalidium tabulatum*			
180.	3675	*Petalostylis labicheoides (Slender Petalostylis)*			
181.	9056	*Phyllanthus baccatus*			
182.	35319	*Phyllanthus hebecarpus*		P3	
183.	4680	*Phyllanthus maderaspatensis*			
184.	5230	*Pimelea ammocharis*			
185.	37720	*Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)*		T	Y
186.	8167	*Pluchea dentex*			
187.	17816	*Pluchea ferdinandi-muelleri*			
188.	43944	*Pluchea longiseta*			
189.	8168	*Pluchea rubelliflora*			
190.	8170	*Pluchea tetranthera*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
191.	2898	*Polycarpaea corymbosa*			
192.	2902	*Polycarpaea involucrata*			
193.	2903	*Polycarpaea longiflora*			
194.	41365	*Polygala glaucifolia*			
195.	41357	*Polygala saccopetala*			
196.	6653	*Polymeria ambigua (Morning Glory)*			
197.	2695	*Ptilotus arthrolasius*			
198.	2696	*Ptilotus astrolasius*			
199.	2698	*Ptilotus auriculifolius*			
200.	2699	*Ptilotus axillaris (Mat Mulla Mulla)*			
201.	2704	*Ptilotus calostachyus (Weeping Mulla Mulla)*			
202.	2711	*Ptilotus clementii (Tassel Top)*			
203.	2725	*Ptilotus fusiformis*			
204.	2734	*Ptilotus incanus*			
205.	2744	*Ptilotus mollis*		P4	
206.	41001	*Ptilotus nobilis subsp. nobilis (Yellow Tails)*			
207.	2582	*Rhagodia eremaea (Thorny Saltbush)*			
208.	13310	*Rhodanthe margarethae*			
209.	4191	*Rhynchosia minima (Rhynchosia)*			
210.	17720	*Rothia indica subsp. australis*		P3	
211.	30434	*Salsola australis*			
212.	13178	*Scaevola amblyanthera var. centralis*			
213.	12579	*Scaevola browniana*			
214.	13150	*Scaevola browniana subsp. browniana*			
215.	7644	*Scaevola spinescens (Currant Bush, Maroon)*			
216.	41660	*Schenkia australis*			
217.	599	*Schizachyrium fragile (Senale Redgrass)*			
218.	48362	*Schoenoplectiella laevis*			
219.	18443	*Senna ferraria*			
220.	12307	*Senna glutinosa subsp. glutinosa*			
221.	12309	*Senna glutinosa subsp. pruinosa*			
222.	46821	*Seringia nephrosperma (Free carpel fire-bush)*			
223.	4196	*Sesbania cannabina (Sesbania Pea)*			
224.	612	*Setaria surgens (Pigeon Grass)*			
225.	4966	*Sida arenicola*			
226.	4970	*Sida calyxhymenia (Tall Sida)*			
227.	4972	*Sida clementii*			
228.	6989	*Solanum ashbyae*			
229.	6998	*Solanum cleistogamum*			
230.	7009	*Solanum gabrielae*			
231.	7014	*Solanum horridum*			
232.	7018	*Solanum lasiophyllum (Flannel Bush, Mindjulu)*			
233.	7029	*Solanum phlomoides*			
234.	619	*Sorghum plumosum (Plume Canegrass)*			
235.	628	*Sporobolus actinocladus (Ray Grass, Katoora)*			
236.	7098	*Stemodia grossa (Marsh Stemodia, Mindjaara)*			
237.	7102	*Stemodia viscosa (Pagurda)*			
238.	8235	*Streptoglossa bubakii*			
239.	8240	*Streptoglossa odora*			
240.	7711	*Stylidium desertorum*			
241.	18123	*Stylidium weeliwolli*		P3	
242.	4223	*Swainsona decurrens*			
243.	12356	*Swainsona formosa*			
244.	4231	*Swainsona kingii*			
245.	7363	*Synaptantha tillaeacea*			
246.	13339	*Synaptantha tillaeacea var. tillaeacea*			
247.	4253	*Templetonia hookeri*			
248.	4263	*Tephrosia clementii*			
249.	19531	*Tephrosia rosea var. clementii*			
250.	19529	*Tephrosia rosea var. rosea*			
251.	15947	*Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)*			
252.	17768	*Tephrosia sp. Bungaroo Creek (M.E. Trudgen 11601)*			
253.	15949	*Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)*			
254.	41811	*Tephrosia sp. Fortescue (A.A. Mitchell 606)*			
255.	20380	*Tephrosia sp. Meentheena (S. van Leeuwen 4479)*			
256.	42442	*Tephrosia sp. NW Eremaean (S. van Leeuwen et al. PBS 0356)*			
257.	4285	*Tephrosia supina*			
258.	4286	*Tephrosia uniovulata*			
259.	4287	*Tephrosia virens*			
260.	45698	*Terminalia circumalata*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
261.	5313	*Terminalia supranitifolia*		P3	
262.	673	*Themeda triandra*			
263.	6278	*Trachymene oleracea*			
264.	19043	*Trachymene oleracea subsp. oleracea*			
265.	44240	*Trianthema cusackianum*			
266.	44241	*Trianthema glossostigmum*			
267.	44261	*Trianthema oxycalyptrum var. oxycalyptrum*			
268.	2830	*Trianthema portulacastrum (Giant Pigweed)*	Y		
269.		*Trianthema sp.*			
270.	44362	*Trianthema triquetrum*			
271.	44360	*Trianthema turgidifolium*			
272.	4375	*Tribulus cistoides*			
273.	4377	*Tribulus hirsutus*			
274.	18072	*Tribulus suberosus*			
275.	6727	*Trichodesma zeylanicum (Camel Bush, Kumbalin)*			
276.	13559	*Trichodesma zeylanicum var. grandiflorum*			
277.	679	*Triodia angusta*			
278.	45769	*Triodia basitricha (Pilbara Curly Spinifex)*		P3	
279.	681	*Triodia brizoides*			
280.	48468	*Triodia chichesterensis*		P3	
281.	13131	*Triodia epactia*			
282.	689	*Triodia lanigera*			
283.	690	*Triodia longiceps (Giant Grey Spinifex)*			
284.	17873	*Triodia schinzii*			
285.	700	*Triodia secunda*			
286.	704	*Triodia wiseana (Limestone Spinifex)*			
287.	48319	*Tripogonella loliiformis*			
288.	4873	*Triumfetta appendiculata*			
289.	4875	*Triumfetta chaetocarpa (Urchins)*			
290.	14694	*Triumfetta clementii*			
291.	16306	*Triumfetta deserticola*			
292.	4878	*Triumfetta johnstonii*			
293.	14942	*Triumfetta maconochieana*			
294.	17317	*Triumfetta propinqua*			
295.	13481	*Triumfetta ramosa*			
296.	11321	*Urochloa holosericea subsp. velutina*			
297.	7654	*Velleia connata (Cup Velleia)*			
298.		*Vigna sp.*			
299.	5107	*Waltheria virgata*			
300.	729	*Xerochloa barbata (Rice Grass)*			
301.	732	*Yakirra australiensis*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX C EPBC PROTECTED MATTERS SEARCH TOOL (50 KM BUFFER)

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

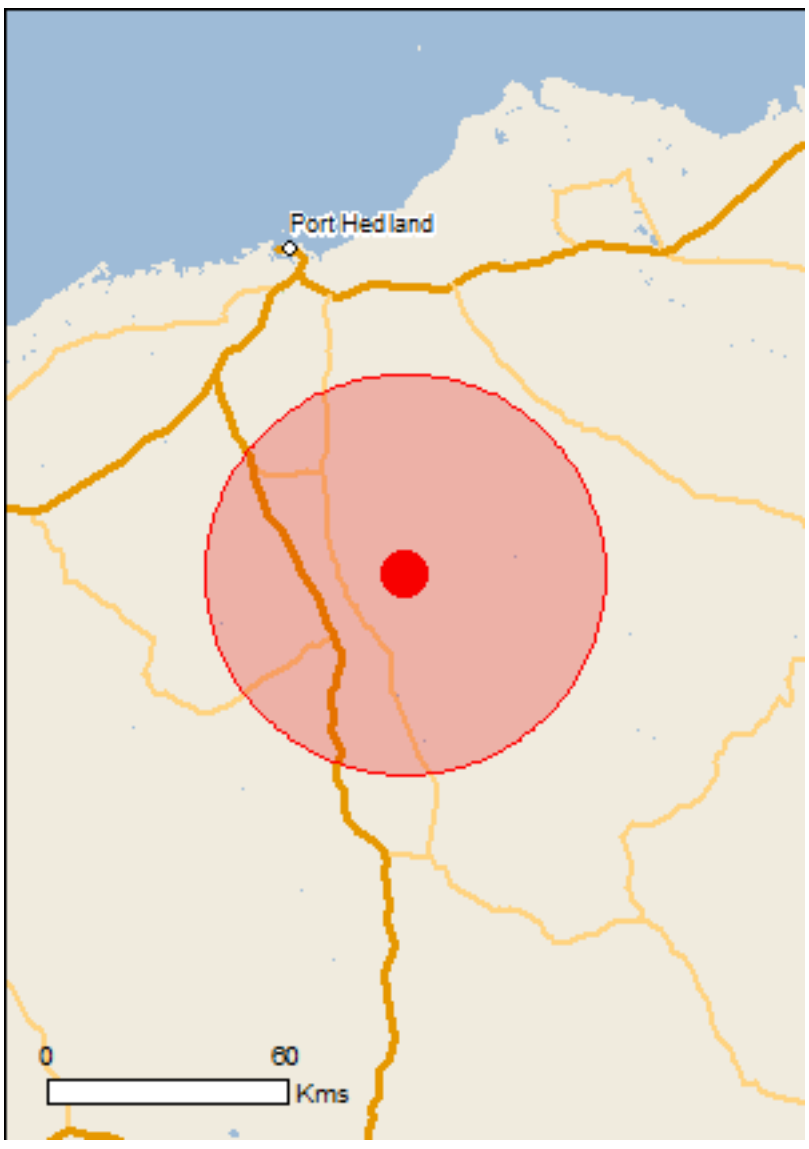
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 05/06/18 11:13:58

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

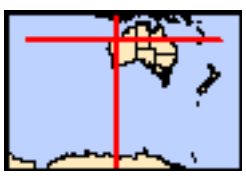
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	10
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Breeding likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Roosting known to occur within area
Plants		
Pityrodia sp. Marble Bar (G.Woodman & D.Coultas GWDC Opp 4) [88310]	Endangered	Species or species habitat known to occur within area
Reptiles		
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur

Name	Threatened	Type of Presence within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat may occur within area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
[Hirundo rustica](#) Barn Swallow [662]		Species or species habitat may occur within area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat likely to occur within area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat likely to occur within area
[Rostratula benghalensis (sensu lato)](#) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-20.99454 118.86366

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D TPFL AND WAHERB DATABASE RECORDS

Taxon	Status	Easting	Northing
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	1	661063	7693030
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	1	675439	7708360
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	1	666962	7705360
Abutilon sp. Pritzelianum (S. van Leeuwen 5095)	1	672172	7710720
Acacia leeuweniana	1	676263	7636320
Acacia leeuweniana	1	677672	7636580
Acacia leeuweniana	1	677672	7636580
Acacia leeuweniana	1	676385	7636930
Acacia leeuweniana	1	677672	7636580
Acacia leeuweniana	1	677672	7636580
Acacia leeuweniana	1	685751	7645580
Acacia leeuweniana	1	677672	7636570
Acacia levata	3	677672	7636580
Acacia levata	3	676385	7636930
Acacia levata	3	677781	7635530
Acacia levata	3	662116	7636740
Bulbostylis burbidgeae	4	673852	7682270
Bulbostylis burbidgeae	4	669691	7697630
Bulbostylis burbidgeae	4	708801	7690270
Bulbostylis burbidgeae	4	676735	7639450
Bulbostylis burbidgeae	4	676488	7689770
Bulbostylis burbidgeae	4	677089	7680410
Bulbostylis burbidgeae	4	673858	7686840
Bulbostylis burbidgeae	4	671622	7696370
Bulbostylis burbidgeae	4	673869	7686850
Bulbostylis burbidgeae	4	699765	7623600
Bulbostylis burbidgeae	4	699579	7624260
Bulbostylis burbidgeae	4	672938	7686290
Bulbostylis burbidgeae	4	687628	7637720
Bulbostylis burbidgeae	4	685109	7653170
Bulbostylis burbidgeae	4	708801	7690270
Bulbostylis burbidgeae	4	673996	7686990
Eragrostis crateriformis	3	694837	7643470
Eragrostis crateriformis	3	677067	7633220
Eragrostis crateriformis	3	675177	7681650
Eragrostis crateriformis	3	672753	7699210
Eragrostis crateriformis	3	666807	7701210
Euphorbia clementii	3	719683	7663490
Euphorbia clementii	3	675071	7655500
Euphorbia clementii	3	673890	7653730
Euphorbia clementii	3	672040	7653610
Euphorbia clementii	3	676668	7656520
Euphorbia clementii	3	672753	7653670
Euphorbia clementii	3	690237	7656500
Euphorbia clementii	3	726310	7666570
Euphorbia clementii	3	675519	7662670
Euphorbia clementii	3	670795	7659500
Euphorbia clementii	3	675034	7660030
Euphorbia clementii	3	686579	7664120
Euphorbia clementii	3	691605	7658990
Euphorbia clementii	3	726133	7666080
Euphorbia clementii	3	676882	7656310
Euphorbia clementii	3	671991	7653680
Euphorbia clementii	3	668509	7658300
Euphorbia clementii	3	670693	7698540
Euphorbia clementii	3	699797	7648960
Euphorbia clementii	3	670244	7663490
Euphorbia clementii	3	672710	7660870
Euphorbia clementii	3	673977	7659310
Fimbristylis sieberiana	3	712392	7635120
Fimbristylis sieberiana	3	706084	7634690
Gomphrena leptophylla	3	662381	7630990
Gomphrena leptophylla	3	683659	7655910
Goodenia nuda	4	676620	7669530
Gymnanthera cunninghamii	3	683812	7656010
Gymnanthera cunninghamii	3	686082	7650970
Gymnanthera cunninghamii	3	675740	7674890
Gymnanthera cunninghamii	3	677057	7669090
Gymnanthera cunninghamii	3	675575	7675490
Gymnanthera cunninghamii	3	677865	7664460
Gymnanthera cunninghamii	3	686082	7650970
Heliotropium muticum	3	682879	7669840
Heliotropium muticum	3	674607	7692750

Taxon	Status	Easting	Northing
Heliotropium muticum	3	683782	7656190
Heliotropium muticum	3	687555	7656380
Heliotropium muticum	3	655703	7689860
Heliotropium muticum	3	702675	7706330
Heliotropium muticum	3	677588	7663860
Heliotropium muticum	3	677609	7663830
Heliotropium muticum	3	686547	7664300
Heliotropium muticum	3	723188	7672230
Heliotropium muticum	3	723175	7672220
Heliotropium muticum	3	723403	7672240
Heliotropium muticum	3	723195	7672250
Heliotropium muticum	3	723265	7672200
Heliotropium muticum	3	723269	7672180
Heliotropium muticum	3	723300	7672170
Heliotropium muticum	3	723210	7672210
Heliotropium muticum	3	723176	7672240
Heliotropium muticum	3	723178	7672240
Heliotropium muticum	3	676107	7677750
Heliotropium muticum	3	674288	7682580
Heliotropium muticum	3	674172	7682540
Heliotropium muticum	3	723185	7672260
Heliotropium muticum	3	676006	7693910
Heliotropium muticum	3	677137	7667850
Heliotropium muticum	3	677460	7664790
Heliotropium muticum	3	666421	7707080
Heliotropium muticum	3	677826	7662580
Heliotropium muticum	3	673440	7684030
Nicotiana umbratica	3	676429	7641190
Nicotiana umbratica	3	698666	7630520
Nicotiana umbratica	3	676561	7664000
Nicotiana umbratica	3	687649	7643740
Nicotiana umbratica	3	685160	7653140
Phyllanthus hebecarpus	3	676326	7641340
Phyllanthus hebecarpus	3	677586	7634510
Phyllanthus hebecarpus	3	686029	7650610
Phyllanthus hebecarpus	3	676475	7641220
Phyllanthus hebecarpus	3	676735	7639450
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	720969	7661120
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	714595	7655540
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	721174	7661320
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	721166	7661280
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717624	7660140
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730447	7662320
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717624	7660140
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	714594	7655530
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	719102	7660270
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730098	7658660
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	720945	7661070
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	720969	7661120
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715804	7650330
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	706355	7653390
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	720969	7661120
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	714095	7655660
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717625	7660140
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730447	7662320
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	719102	7660270
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	703596	7654000
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	705379	7649380
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	708299	7652020
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	710208	7657990
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	710278	7656900
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	710231	7655950
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	712319	7655590
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	714935	7655050
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	712268	7652560
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	713381	7651750
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715350	7649360
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715676	7645770
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	714681	7644800
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717040	7654170
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717912	7654420
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717242	7655340
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	718688	7656250

Taxon	Status	Easting	Northing
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	720708	7656200
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	719553	7659960
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	721698	7661920
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730039	7659250
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730098	7658670
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	733670	7658650
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	732002	7659880
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	733197	7660470
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	731727	7662360
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	732752	7662980
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	734307	7663440
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	734050	7664120
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	730804	7663620
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	729703	7666910
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	718179	7657960
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	717117	7659060
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715058	7657380
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715130	7659380
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	702805	7654820
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	703584	7652900
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	706593	7652570
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	706355	7653390
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	709611	7657220
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	709378	7655930
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	710970	7651780
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	710592	7653520
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	711148	7656700
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	713206	7653780
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715955	7650400
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	715849	7654780
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	716351	7654480
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	716351	7654480
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	735569	7652850
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	736438	7655640
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	736777	7656290
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	735593	7658360
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	736945	7658360
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	737703	7658200
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	735928	7659470
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	737507	7659610
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	738443	7659310
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	737836	7660560
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	738987	7661840
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	736651	7662350
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	737151	7662690
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	738716	7663700
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	739597	7663440
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	738819	7664830
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T	704714	7648840
Ptilotus mollis	4	714511	7646820
Ptilotus mollis	4	715315	7623090
Ptilotus mollis	4	713535	7626090
Ptilotus mollis	4	713730	7624270
Rothia indica subsp. australis	3	672343	7686880
Stylidium weeliwolli	3	673724	7682500
Stylidium weeliwolli	3	686937	7645480
Terminalia supranitifolia	3	671485	7657920
Terminalia supranitifolia	3	671334	7657880
Terminalia supranitifolia	3	674759	7657000
Terminalia supranitifolia	3	688747	7662330
Triodia basitricha	3	721002	7661860
Triodia chichesterensis	3	679323	7674140
Triodia chichesterensis	3	675669	7711520
Triodia chichesterensis	3	698576	7623140
Triodia chichesterensis	3	698576	7623140
Triodia chichesterensis	3	698576	7623140
Triodia chichesterensis	3	698576	7623140
Triodia chichesterensis	3	698576	7623140
Triodia chichesterensis	3	681816	7669480
Triodia chichesterensis	3	668918	7710150
Triodia chichesterensis	3	702675	7706330
Triodia chichesterensis	3	690069	7634320
Triodia chichesterensis	3	697005	7636080

Taxon	Status	Easting	Northing
Triodia chichesterensis	3	699434	7639100

APPENDIX E VERTEBRATE FAUNA RECORDS. NATUREMAP (40 KM BUFFER)

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only Yes
Core Datasets Only Yes
Species Group Mammals
Method 'By Circle'
Centre 118° 52' 26" E,21° 04' 28" S
Buffer 30km

Area (ha)		282680.66
Taxa:	Naturalised	9
	Native	39
Endemics:		0
Families:		16
Genera:		32
Conservation Status:	-	38
	T	4
	4	6
MS Status:	-	47
	PN	1
Rank:	-	44
	subsp.	4

Top Ten Families

		Species	Records
1.	Dasyuridae	13	657
2.	Muridae	7	564
3.	Macropodidae	7	237
4.	Vespertilionidae	4	185
5.	Canidae	3	21
6.	Emballonuridae	2	124
7.	Equidae	2	5
8.	Hipposideridae	2	81
9.	Phalangeridae	1	2
10.	Felidae	1	51

Top Ten Genera

		Species	Records
1.	*Pseudomys*	4	134
2.	*Sminthopsis*	4	15
3.	*Macropus*	4	48
4.	*Pseudantechinus*	3	16
5.	*Rhinonicteris*	2	81
6.	*Lagorchestes*	2	138
7.	*Canis*	2	20
8.	*Planigale*	2	27
9.	*Equus*	2	5
10.	*Notomys*	1	5

[1]Endemic To Query Area

Name ID	Species	Conservation Status

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only Yes
Core Datasets Only Yes
Species Group Mammals
Method 'By Circle'
Centre 118° 52' 26" E,21° 04' 28" S
Buffer 30km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	24251	*Bos taurus (European Cattle)*	Y		
2.	24254	*Camelus dromedarius (Dromedary, Camel)*	Y		
3.	25454	*Canis lupus (Dog, Dingo)*	Y		
4.	24039	*Canis lupus subsp. dingo (Dingo)*	Y		
5.	24181	*Chaerephon jobensis (Greater Northern Freetail-bat, Northern Mastiff Bat)*			
6.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
7.	30903	*Dasycercus blythi (Brush-tailed Mulgara, Ampurta)*		P4	
8.	24091	*Dasykaluta rosamondae (Little Red Kaluta)*			
9.	24093	*Dasyurus hallucatus (Northern Quoll)*		T	
10.	24257	*Equus asinus (Donkey)*	Y		
11.	24258	*Equus caballus (Horse)*	Y		
12.	24041	*Felis catus (Cat)*	Y		
13.	25479	*Lagorchestes conspicillatus (Spectacled Hare-wallaby)*		P4	
14.	24122	*Lagorchestes conspicillatus subsp. leichardti (Spectacled Hare-wallaby (mainland))*		P4	
15.	24180	*Macroderma gigas (Ghost Bat)*		T	
16.	24129	*Macropus agilis (Agile Wallaby)*			
17.	25489	*Macropus robustus (Euro, Biggada)*			
18.	24135	*Macropus robustus subsp. erubescens (Euro, Biggada)*			
19.	24136	*Macropus rufus (Red Kangaroo, Marlu)*			
20.	24168	*Macrotis lagotis (Bilby, Dalgyte, Ninu)*		T	
21.	24223	*Mus musculus (House Mouse)*	Y		
22.	24095	*Ningaui timealeyi (Pilbara Ningaui)*			
23.	24224	*Notomys alexis (Spinifex Hopping-mouse)*			
24.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
25.	24144	*Petrogale rothschildi (Rothschild's Rock-wallaby)*			
26.	24101	*Planigale ingrami (Long-tailed Planigale)*			
27.	24102	*Planigale maculata (Common Planigale)*			
28.	24103	*Pseudantechinus macdonnellensis (Fat-tailed Pseudantechinus)*			
29.	24105	*Pseudantechinus roryi (Rory's Pseudantechinus)*			
30.	24106	*Pseudantechinus woolleyae (Woolley's Pseudantechinus)*			
31.	24233	*Pseudomys chapmani (Western Pebble-mound Mouse, Ngadji)*		P4	
32.	24234	*Pseudomys delicatulus (Delicate Mouse)*			
33.	24235	*Pseudomys desertor (Desert Mouse)*			
34.	24237	*Pseudomys hermannsburgensis (Sandy Inland Mouse)*			
35.	43368	*Rhinonicteris aurantia (Orange Leaf-nosed bat)*		P4	
36.	48095	*Rhinonicteris aurantia (Pilbara) (Pilbara leaf-nosed bat)*		T	
37.	24174	*Saccolaimus flaviventris (Yellow-bellied Sheath-tailed Bat)*			
38.	24200	*Scotorepens greyii (Little Broad-nosed Bat)*			
39.	24115	*Sminthopsis longicaudata (Long-tailed Dunnart)*		P4	
40.	24116	*Sminthopsis macroura (Stripe-faced Dunnart)*			
41.	24117	*Sminthopsis ooldea (Ooldea Dunnart)*			
42.	24120	*Sminthopsis youngsoni (Lesser Hairy-footed Dunnart)*			
43.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
44.	24175	*Taphozous georgianus (Common Sheath-tailed Bat)*			
45.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
46.	24205	*Vespadelus finlaysoni (Finlayson's Cave Bat)*			
47.	24040	*Vulpes vulpes (Red Fox)*	Y		
48.	24248	*Zyzomys argurus (Common Rock-rat)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement

Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area

S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only	Yes
Core Datasets Only	Yes
Species Group	Birds
Method	'By Circle'
Centre	118° 52' 26" E,21° 04' 28" S
Buffer	30km

Area (ha)		282680.66
Taxa:	Naturalised	0
	Native	131
Endemics:		0
Families:		49
Genera:		94
Conservation Status:	-	126
	T	1
	IA	2
	S	1
	4	1
MS Status:	-	131
Rank:	-	123
	subsp.	8

Top Ten Families

		Species	Records
1.	Accipitridae	12	108
2.	Meliphagidae	9	229
3.	Falconidae	7	92
4.	Psittacidae	6	137
5.	Ardeidae	6	44
6.	Columbidae	5	314
7.	Anatidae	5	27
8.	Artamidae	5	90
9.	Maluridae	4	92
10.	Dicruridae	4	214

Top Ten Genera

		Species	Records
1.	*Falco*	7	92
2.	*Artamus*	5	90
3.	*Ardea*	4	28
4.	*Rhipidura*	3	105
5.	*Accipiter*	3	31
6.	*Cracticus*	3	100
7.	*Phalacrocorax*	3	5
8.	*Corvus*	3	104
9.	*Egretta*	2	16
10.	*Ephippiorhynchus*	2	8

[1]Endemic To Query Area

Name ID	Species	Conservation Status

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
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1 - Priority 1
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[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only Yes
Core Datasets Only Yes
Species Group Birds
Method 'By Circle'
Centre 118° 52' 26" E,21° 04' 28" S
Buffer 30km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
2.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
3.	24281	*Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)*			
4.	25536	*Accipiter fasciatus (Brown Goshawk)*			
5.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
6.	25544	*Aegotheles cristatus (Australian Owlet-nightjar)*			
7.	25647	*Amytornis striatus (Striated Grasswren)*			
8.	24539	*Amytornis striatus subsp. striatus (Striated Grasswren (inland))*		P4	
9.	24312	*Anas gracilis (Grey Teal)*			
10.	24316	*Anas superciliosa (Pacific Black Duck)*			
11.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
12.	25670	*Anthus australis (Australian Pipit)*			
13.	25554	*Apus pacificus (Fork-tailed Swift, Pacific Swift)*		IA	
14.	24285	*Aquila audax (Wedge-tailed Eagle)*			
15.	25557	*Ardea garzetta (Little Egret)*			
16.	41324	*Ardea modesta (great egret, white egret)*			
17.	24340	*Ardea novaehollandiae (White-faced Heron)*			
18.	24341	*Ardea pacifica (White-necked Heron)*			
19.	24610	*Ardeotis australis (Australian Bustard)*			
20.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
21.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
22.	25567	*Artamus leucorynchus (White-breasted Woodswallow)*			
23.	24355	*Artamus minor (Little Woodswallow)*			
24.	24356	*Artamus personatus (Masked Woodswallow)*			
25.	24318	*Aythya australis (Hardhead)*			
26.		*Barnardius zonarius*			
27.	24359	*Burhinus grallarius (Bush Stone-curlew)*			
28.	25715	*Cacatua roseicapilla (Galah)*			
29.	25716	*Cacatua sanguinea (Little Corella)*			
30.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
31.	25600	*Centropus phasianinus (Pheasant Coucal)*			
32.	24564	*Certhionyx variegatus (Pied Honeyeater)*			
33.	24378	*Charadrius veredus (Oriental Plover)*		IA	
34.	24431	*Chrysococcyx basalis (Horsfield's Bronze Cuckoo)*			
35.	24289	*Circus assimilis (Spotted Harrier)*			
36.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
37.	24611	*Colluricincla harmonica subsp. brunnea (Grey Shrike-thrush)*			
38.	24361	*Coracina maxima (Ground Cuckoo-shrike)*			
39.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
40.	24416	*Corvus bennetti (Little Crow)*			
41.	25593	*Corvus orru (Torresian Crow)*			
42.	24418	*Corvus orru subsp. cecilae (Western Crow)*			
43.	25701	*Coturnix ypsilophora (Brown Quail)*			
44.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
45.	25595	*Cracticus tibicen (Australian Magpie)*			
46.	25596	*Cracticus torquatus (Grey Butcherbird)*			
47.	24322	*Cygnus atratus (Black Swan)*			
48.	25547	*Dacelo leachii (Blue-winged Kookaburra)*			
49.	24325	*Dendrocygna eytoni (Plumed Whistling Duck)*			
50.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
51.		*Egretta garzetta*			
52.		*Egretta novaehollandiae*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
53.		*Elanus axillaris*			
54.	25540	*Elanus caeruleus (Black-shouldered Kite)*			
55.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
56.	24631	*Emblema pictum (Painted Finch)*			
57.		*Eolophus roseicapillus*			
58.	25578	*Ephippiorhynchus asiaticus (Black-necked Stork)*			
59.	24387	*Ephippiorhynchus asiaticus subsp. australis (Black-necked Stork)*			
60.	24570	*Epthianura tricolor (Crimson Chat)*			
61.	24837	*Eremiornis carteri (Spinifex-bird)*			
62.	24368	*Eurostopodus argus (Spotted Nightjar)*			
63.	25621	*Falco berigora (Brown Falcon)*			
64.	24471	*Falco berigora subsp. berigora (Brown Falcon)*			
65.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
66.	24473	*Falco hypoleucos (Grey Falcon)*		T	
67.	25623	*Falco longipennis (Australian Hobby)*			
68.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
69.	24476	*Falco subniger (Black Falcon)*			
70.	25727	*Fulica atra (Eurasian Coot)*			
71.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
72.	42314	*Gavicalis virescens (Singing Honeyeater)*			
73.	24401	*Geopelia cuneata (Diamond Dove)*			
74.	25585	*Geopelia striata (Zebra Dove)*			
75.	24404	*Geophaps plumifera (Spinifex Pigeon)*			
76.	25530	*Gerygone fusca (Western Gerygone)*			
77.	24443	*Grallina cyanoleuca (Magpie-lark)*			
78.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
79.	24295	*Haliastur sphenurus (Whistling Kite)*			
80.	24296	*Hamirostra isura (Square-tailed Kite)*			
81.	47965	*Hieraaetus morphnoides (Little Eagle)*			
82.	25734	*Himantopus himantopus (Black-winged Stilt)*			
83.	24491	*Hirundo neoxena (Welcome Swallow)*			
84.	24572	*Lacustroica whitei (Grey Honeyeater)*			
85.	24367	*Lalage tricolor (White-winged Triller)*			
86.	25661	*Lichmera indistincta (Brown Honeyeater)*			
87.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
88.	25652	*Malurus leucopterus (White-winged Fairy-wren)*			
89.	24583	*Manorina flavigula (Yellow-throated Miner)*			
90.	47997	*Melanodryas cucullata (Hooded Robin)*			
91.	25665	*Melithreptus gularis (Black-chinned Honeyeater)*			
92.	24736	*Melopsittacus undulatus (Budgerigar)*			
93.	24598	*Merops ornatus (Rainbow Bee-eater)*			
94.		*Microcarbo melanoleucos*			
95.	25542	*Milvus migrans (Black Kite)*			
96.	25545	*Mirafra javanica (Horsfield's Bushlark, Singing Bushlark)*			
97.	25685	*Neochmia ruficauda (Star Finch)*			
98.	24742	*Nymphicus hollandicus (Cockatiel)*			
99.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
100.	24618	*Oreoica gutturalis (Crested Bellbird)*			
101.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
102.	24627	*Pardalotus rubricatus (Red-browed Pardalote)*			
103.	25682	*Pardalotus striatus (Striated Pardalote)*			
104.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
105.	48060	*Petrochelidon ariel (Fairy Martin)*			
106.	48061	*Petrochelidon nigricans (Tree Martin)*			
107.	24659	*Petroica goodenovii (Red-capped Robin)*			
108.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
109.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
110.	25699	*Phalacrocorax varius (Pied Cormorant)*			
111.	24409	*Phaps chalcoptera (Common Bronzewing)*			
112.	24842	*Platalea regia (Royal Spoonbill)*			
113.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
114.	25703	*Podargus strigoides (Tawny Frogmouth)*			
115.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
116.	25706	*Pomatostomus temporalis (Grey-crowned Babbler)*			
117.		*Ptilonorhynchus guttatus*			
118.	24757	*Ptilonorhynchus maculatus subsp. guttatus (Western Bowerbird)*			
119.	42323	*Ptilotula keartlandi (Grey-headed Honeyeater)*			
120.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
121.	24454	*Rhipidura leucophrys subsp. leucophrys (Willie Wagtail)*			
122.	25616	*Rhipidura rufiventris (Northern Fantail)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
123.	30948	*Smicrornis brevirostris (Weebill)*			
124.	25643	*Sterna hybrida (Whiskered Tern)*			
125.	24482	*Stiltia isabella (Australian Pratincole)*			
126.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
127.	30870	*Taeniopygia guttata (Zebra Finch)*			
128.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
129.	42351	*Todiramphus pyrrhopygius (Red-backed Kingfisher)*			
130.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
131.	24851	*Turnix velox (Little Button-quail)*			

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S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only	Yes
Core Datasets Only	Yes
Species Group	Reptiles
Method	'By Circle'
Centre	118° 52' 26" E,21° 04' 28" S
Buffer	30km

Area (ha)		282680.66
Taxa:	Naturalised	0
	Native	112
Endemics:		0
Families:		10
Genera:		43
Conservation Status:	-	111
	T	1
MS Status:	-	112
Rank:	-	95
	subsp.	17

Top Ten Families

		Species	Records
1.	Scincidae	41	1487
2.	Agamidae	12	360
3.	Varanidae	12	227
4.	Elapidae	12	96
5.	Diplodactylidae	11	313
6.	Pygopodidae	9	93
7.	Gekkonidae	6	349
8.	Boidae	6	73
9.	Carphodactylidae	2	4
10.	Cheluidae	1	4

Top Ten Genera

		Species	Records
1.	*Ctenotus*	16	872
2.	*Varanus*	12	227
3.	*Delma*	7	71
4.	*Ctenophorus*	6	312
5.	*Lerista*	6	180
6.	*Egernia*	4	60
7.	*Antaresia*	3	32
8.	*Heteronotia*	3	183
9.	*Demansia*	3	23
10.	*Diplodactylus*	3	120

[1] Endemic To Query Area

Name ID	Species	Conservation Status

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
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NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only Yes
Core Datasets Only Yes
Species Group Reptiles
Method 'By Circle'
Centre 118° 52' 26" E,21° 04' 28" S
Buffer 30km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	25332	*Acanthophis wellsi (Pilbara Death Adder)*			
2.	30833	*Amphibolurus longirostris (Long-nosed Dragon)*			
3.	25318	*Antaresia perthensis (Pygmy Python)*			
4.	25448	*Antaresia stimsoni (Stimson's Python)*			
5.	25241	*Antaresia stimsoni subsp. stimsoni (Stimson's Python)*			
6.	25320	*Aspidites melanocephalus (Black-headed Python)*			
7.	25331	*Brachyurophis approximans (North-western Shovel-nosed Snake)*			
8.	25015	*Carlia munda (Shaded-litter Rainbow Skink)*			
9.	25017	*Carlia triacantha (Desert Rainbow Skink)*			
10.	25339	*Chelodina steindachneri (Flat-shelled Turtle)*			
11.	25456	*Crenadactylus ocellatus (Clawless Gecko)*			
12.	24919	*Crenadactylus ocellatus subsp. horni (Clawless Gecko)*			
13.	30893	*Cryptoblepharus buchananii*			
14.	30892	*Cryptoblepharus ustulatus*			
15.	25458	*Ctenophorus caudicinctus (Ring-tailed Dragon)*			
16.	24865	*Ctenophorus caudicinctus subsp. caudicinctus (Ring-tailed Dragon)*			
17.	25459	*Ctenophorus isolepis (Crested Dragon, Military Dragon)*			
18.	24876	*Ctenophorus isolepis subsp. isolepis (Crested Dragon, Military Dragon)*			
19.	24882	*Ctenophorus nuchalis (Central Netted Dragon)*			
20.	24886	*Ctenophorus reticulatus (Western Netted Dragon)*			
21.	25036	*Ctenotus duricola*			
22.	25039	*Ctenotus fallens*			
23.	25462	*Ctenotus grandis*			
24.	25043	*Ctenotus grandis subsp. titan*			
25.	25044	*Ctenotus hanloni*			
26.	25045	*Ctenotus helenae*			
27.	25048	*Ctenotus inornatus*			
28.	25052	*Ctenotus leonhardii*			
29.	25463	*Ctenotus pantherinus (Leopard Ctenotus)*			
30.	25064	*Ctenotus pantherinus subsp. ocellifer (Leopard Ctenotus)*			
31.	25065	*Ctenotus pantherinus subsp. pantherinus (Leopard Ctenotus)*			
32.	25062	*Ctenotus piankai*			
33.	25072	*Ctenotus rubicundus*			
34.	25073	*Ctenotus saxatilis (Rock Ctenotus)*			
35.	25074	*Ctenotus schomburgkii*			
36.	25077	*Ctenotus serventyi*			
37.	25466	*Cyclodomorphus melanops (Slender Blue-tongue)*			
38.	25090	*Cyclodomorphus melanops subsp. melanops (Slender Blue-tongue)*			
39.	24997	*Delma butleri*			
40.	24998	*Delma elegans*			
41.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
42.	25000	*Delma haroldi*			
43.	25001	*Delma nasuta*			
44.	25002	*Delma pax*			
45.	25004	*Delma tincta*			
46.	25468	*Demansia psammophis (Yellow-faced Whipsnake)*			
47.	25295	*Demansia psammophis subsp. cupreiceps (Yellow-faced Whipsnake)*			
48.	25297	*Demansia rufescens (Rufous Whipsnake)*			
49.	24926	*Diplodactylus conspicillatus (Fat-tailed Gecko)*			
50.	41404	*Diplodactylus galaxias (Northern Pilbara Beak-faced Gecko)*			
51.	24944	*Diplodactylus savagei (Southern Pilbara Beak-faced Gecko)*			
52.	24899	*Diporiphora valens (Southern Pilbara Tree Dragon)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
53.	42402	*Diporiphora vescus (Northern Pilbara Tree Dragon)*			
54.	41406	*Egernia cygnitos (Western Pilbara Spiny-tailed Skink)*			
55.	25092	*Egernia depressa (Southern Pygmy Spiny-tailed Skink)*			
56.	41408	*Egernia epsisolus (Eastern Pilbara Spiny-tailed Skink)*			
57.	25094	*Egernia formosa*			
58.	25109	*Eremiascincus richardsonii (Broad-banded Sand Swimmer)*			
59.	25301	*Furina ornata (Moon Snake)*			
60.	24956	*Gehyra pilbara*			
61.	24958	*Gehyra punctata*			
62.	24959	*Gehyra variegata*			
63.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
64.	24963	*Heteronotia planiceps*			
65.	24962	*Heteronotia spelea (Desert Cave Gecko, Pilbara Cave Gecko)*			
66.	25125	*Lerista bipes*			
67.	30928	*Lerista clara*			
68.	30929	*Lerista jacksoni*			
69.	25146	*Lerista labialis*			
70.	25155	*Lerista muelleri*			
71.	30925	*Lerista verhmens*			
72.	25005	*Lialis burtonis*			
73.	25486	*Liasis olivaceus (Olive Python)*			
74.	25238	*Liasis olivaceus subsp. barroni (Pilbara Olive Python)*		T	
75.	30933	*Lucasium stenodactylum*			
76.	30934	*Lucasium wombeyi*			
77.	25184	*Menetia greyii*			
78.	25491	*Menetia surda*			
79.	25495	*Morethia ruficauda*			
80.	25193	*Morethia ruficauda subsp. exquisita*			
81.	25497	*Nephrurus levis*			
82.	24969	*Nephrurus levis subsp. pilbarensis*			
83.	25499	*Notoscincus ornatus*			
84.	25197	*Notoscincus ornatus subsp. ornatus*			
85.	24976	*Oedura marmorata (Marbled Velvet Gecko)*			
86.	25254	*Parasuta monachus*			
87.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
88.	24908	*Pogona minor subsp. mitchelli (Dwarf Bearded Dragon)*			
89.	25199	*Proablepharus reginae*			
90.	25261	*Pseudechis australis (Mulga Snake)*			
91.	25263	*Pseudonaja modesta (Ringed Brown Snake)*			
92.	25264	*Pseudonaja nuchalis (Gwardar, Northern Brown Snake)*			
93.	25009	*Pygopus nigriceps*			
94.	24982	*Rhynchoedura ornata (Western Beaked Gecko)*			
95.	24927	*Strophurus elderi*			
96.	24932	*Strophurus jeanae*			
97.	25269	*Suta fasciata (Rosen's Snake)*			
98.	25202	*Tiliqua multifasciata (Central Blue-tongue)*			
99.	30814	*Tympanocryptis cephalus (Pebble Dragon)*			
100.	25209	*Varanus acanthurus (Spiny-tailed Monitor)*			
101.	25210	*Varanus brevicauda (Short-tailed Pygmy Monitor)*			
102.	25212	*Varanus eremius (Pygmy Desert Monitor)*			
103.	25216	*Varanus giganteus (Perentie)*			
104.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
105.	25524	*Varanus panoptes (Yellow-spotted Monitor)*			
106.	25222	*Varanus panoptes subsp. panoptes*			
107.	25223	*Varanus panoptes subsp. rubidus*			
108.	25224	*Varanus pilbarensis (Pilbara Rock Monitor, Northern Pilbara Rock Goanna)*			
109.		*Varanus sp.*			
110.	25526	*Varanus tristis (Racehorse Monitor)*			
111.	25227	*Varanus tristis subsp. tristis (Racehorse Monitor)*			
112.	25311	*Vermicella snelli*			

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[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

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NatureMap Species Report

Created By Tim McCabe on 05/06/2018

Current Names Only Yes
Core Datasets Only Yes
Species Group Amphibians
Method 'By Circle'
Centre 118° 52' 26" E,21° 04' 28" S
Buffer 30km

Area (ha)		282680.66
Taxa:	Naturalised	0
	Native	10
Endemics:		0
Families:		4
Genera:		6
Conservation Status:	-	10
MS Status:	-	10
Rank:	-	10

Top Ten Families

		Species	Records
1.	Hylidae	3	98
2.	Limnodynastidae	3	19
3.	Myobatrachidae	3	77
4.	Bufonidae	1	2

Top Ten Genera

		Species	Records
1.	*Uperoleia*	3	77
2.	*Neobatrachus*	2	2
3.	*Cyclorana*	2	63
4.	*Notaden*	1	17
5.	*Litoria*	1	35
6.	*Platyplectrum*	1	2

[1]Endemic To Query Area

Name ID	Species	Conservation Status

Conservation Codes
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Current Names Only	Yes
Core Datasets Only	Yes
Species Group	Amphibians
Method	'By Circle'
Centre	118° 52' 26" E,21° 04' 28" S
Buffer	30km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	25371	*Cyclorana australis (Giant Frog)*			
2.	25375	*Cyclorana maini (Sheep Frog)*			
3.	25392	*Litoria rubella (Little Red Tree Frog)*			
4.	25422	*Neobatrachus aquilonius (Northern Burrowing Frog)*			
5.	25427	*Neobatrachus sutor (Shoemaker Frog)*			
6.	25430	*Notaden nichollsi (Desert Spadefoot)*			
7.	42306	*Platyplectrum spenceri (Centralian Burrowing Frog)*			
8.	25439	*Uperoleia glandulosa (Glandular Toadlet)*			
9.	25445	*Uperoleia russelli (Northwest Toadlet)*			
10.	41428	*Uperoleia saxatilis (Pilbara Toadlet)*			

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APPENDIX F BIRDLIFE AUSTRALIA RECORDS (50 KM BUFFER)

Common Name	Scientific Name	Count	Reporting Rate
Emu	Dromaius novaehollandiae	3	1.04%
Plumed Whistling-Duck	Dendrocygna eytoni	1	0.35%
Pink-eared Duck	Malacorhynchus membranaceus	2	0.69%
Black Swan	Cygnus atratus	3	1.04%
Hardhead	Aythya australis	4	1.38%
Pacific Black Duck	Anas superciliosa	21	7.27%
Grey Teal	Anas gracilis	17	5.88%
Australian Wood Duck	Chenonetta jubata	1	0.35%
Brown Quail	Synoicus ypsilophora	4	1.38%
Australasian Grebe	Tachybaptus novaehollandiae	10	3.46%
Hoary-headed Grebe	Poliocephalus poliocephalus	1	0.35%
Spinifex Pigeon	Geophaps plumifera	139	48.10%
Common Bronzewing	Phaps chalcoptera	12	4.15%
Crested Pigeon	Ocyphaps lophotes	120	41.52%
Diamond Dove	Geopelia cuneata	130	44.98%
Peaceful Dove	Geopelia placida	21	7.27%
Pheasant Coucal	Centropus phasianinus	33	11.42%
Horsfield's Bronze-Cuckoo	Chalcites basalis	11	3.81%
Black-eared Cuckoo	Chalcites osculans	4	1.38%
Pallid Cuckoo	Heteroscenes pallidus	26	9.00%
Australian Bustard	Ardeotis australis	29	10.03%
Tawny Frogmouth	Podargus strigoides	3	1.04%
Spotted Nightjar	Eurostopodus argus	36	12.46%
Australian Owlet-nightjar	Aegotheles cristatus	8	2.77%
Fork-tailed Swift	Apus pacificus	8	2.77%
Black-tailed Native-hen	Tribonyx ventralis	1	0.35%
Bush Stone-curlew	Burhinus grallarius	26	9.00%
Black-winged Stilt	Himantopus leucocephalus	1	0.35%
Oriental Plover	Charadrius veredus	2	0.69%
Black-fronted Dotterel	Elseyornis melanops	40	13.84%
Masked Lapwing	Vanellus miles	1	0.35%
Red-kneed Dotterel	Erythrogonys cinctus	3	1.04%
Common Sandpiper	Actitis hypoleucos	3	1.04%
Common Greenshank	Tringa nebularia	1	0.35%
Little Button-quail	Turnix velox	16	5.54%
Oriental Pratincole	Glareola maldivarum	6	2.08%
Silver Gull	Chroicocephalus novaehollandiae	2	0.69%
Caspian Tern	Hydroprogne caspia	1	0.35%
Black-necked Stork	Ephippiorhynchus asiaticus	7	2.42%
Australian Pelican	Pelecanus conspicillatus	9	3.11%
Nankeen Night-Heron	Nycticorax caledonicus	5	1.73%
White-necked Heron	Ardea pacifica	27	9.34%

Common Name	Scientific Name	Count	Reporting Rate
Great Egret	Ardea alba	19	6.57%
White-faced Heron	Egretta novaehollandiae	33	11.42%
Little Egret	Egretta garzetta	6	2.08%
Australian White Ibis	Threskiornis moluccus	2	0.69%
Straw-necked Ibis	Threskiornis spinicollis	15	5.19%
Yellow-billed Spoonbill	Platalea flavipes	3	1.04%
Royal Spoonbill	Platalea regia	2	0.69%
Little Pied Cormorant	Microcarbo melanoleucos	10	3.46%
Great Cormorant	Phalacrocorax carbo	2	0.69%
Little Black Cormorant	Phalacrocorax sulcirostris	12	4.15%
Australasian Darter	Anhinga novaehollandiae	7	2.42%
Black-shouldered Kite	Elanus axillaris	4	1.38%
Wedge-tailed Eagle	Aquila audax	16	5.54%
Little Eagle	Hieraaetus morphnoides	24	8.30%
Spotted Harrier	Circus assimilis	24	8.30%
Brown Goshawk	Accipiter fasciatus	15	5.19%
Collared Sparrowhawk	Accipiter cirrocephalus	18	6.23%
White-bellied Sea-Eagle	Haliaeetus leucogaster	2	0.69%
Whistling Kite	Haliastur sphenurus	30	10.38%
Brahminy Kite	Haliastur indus	1	0.35%
Black Kite	Milvus migrans	7	2.42%
Barn Owl	Tyto alba	1	0.35%
Barking Owl	Ninox connivens	3	1.04%
Southern Boobook	Ninox boobook	57	19.72%
Rainbow Bee-eater	Merops ornatus	85	29.41%
Sacred Kingfisher	Todiramphus sanctus	35	12.11%
Red-backed Kingfisher	Todiramphus pyrrhopygius	40	13.84%
Blue-winged Kookaburra	Dacelo leachii	53	18.34%
Nankeen Kestrel	Falco cenchroides	66	22.84%
Australian Hobby	Falco longipennis	8	2.77%
Brown Falcon	Falco berigora	57	19.72%
Grey Falcon	Falco hypoleucos	3	1.04%
Black Falcon	Falco subniger	1	0.35%
Peregrine Falcon	Falco peregrinus	2	0.69%
Cockatiel	Nymphicus hollandicus	19	6.57%
Galah	Eolophus roseicapilla	125	43.25%
Little Corella	Cacatua sanguinea	62	21.45%
Australian Ringneck	Barnardius zonarius	42	14.53%
Budgerigar	Melopsittacus undulatus	39	13.49%
Western Bowerbird	Ptilonorhynchus guttatus	18	6.23%
Black-tailed Treecreeper	Climacteris melanurus	1	0.35%
Variegated Fairy-wren	Malurus lamberti	44	15.22%
White-winged Fairy-wren	Malurus leucopterus	25	8.65%

Rufous-crowned Emu-wren	Stipiturus ruficeps	3	1.04%
Common Name	**Scientific Name**	**Count**	**Reporting Rate**
Striated Grasswren	Amytornis striatus	12	4.15%
Black Honeyeater	Sugomel niger	1	0.35%
Brown Honeyeater	Lichmera indistincta	118	40.83%
Black-chinned Honeyeater	Melithreptus gularis	44	15.22%
Pied Honeyeater	Certhionyx variegatus	4	1.38%
Crimson Chat	Epthianura tricolor	15	5.19%
Spiny-cheeked Honeyeater	Acanthagenys rufogularis	1	0.35%
Singing Honeyeater	Gavicalis virescens	133	46.02%
Grey-headed Honeyeater	Ptilotula keartlandi	97	33.56%
White-plumed Honeyeater	Ptilotula penicillata	119	41.18%
Yellow-throated Miner	Manorina flavigula	112	38.75%
Red-browed Pardalote	Pardalotus rubricatus	39	13.49%
Striated Pardalote	Pardalotus striatus	1	0.35%
Western Gerygone	Gerygone fusca	3	1.04%
Weebill	Smicrornis brevirostris	1	0.35%
Grey-crowned Babbler	Pomatostomus temporalis	13	4.50%
Ground Cuckoo-shrike	Coracina maxima	1	0.35%
Black-faced Cuckoo-shrike	Coracina novaehollandiae	120	41.52%
White-winged Triller	Lalage tricolor	39	13.49%
Rufous Whistler	Pachycephala rufiventris	14	4.84%
Grey Shrike-thrush	Colluricincla harmonica	45	15.57%
Crested Bellbird	Oreoica gutturalis	29	10.03%
Australian Magpie	Gymnorhina tibicen	36	12.46%
Pied Butcherbird	Cracticus nigrogularis	85	29.41%
Grey Butcherbird	Cracticus torquatus	2	0.69%
Masked Woodswallow	Artamus personatus	7	2.42%
Black-faced Woodswallow	Artamus cinereus	105	36.33%
Little Woodswallow	Artamus minor	10	3.46%
White-breasted Woodswallow	Artamus leucorynchus	2	0.69%
Willie Wagtail	Rhipidura leucophrys	134	46.37%
Torresian Crow	Corvus orru	50	17.30%
Little Crow	Corvus bennetti	2	0.69%
Magpie-lark	Grallina cyanoleuca	142	49.13%
Hooded Robin	Melanodryas cucullata	5	1.73%
Mistletoebird	Dicaeum hirundinaceum	5	1.73%
Painted Finch	Emblema pictum	85	29.41%
Star Finch	Neochmia ruficauda	4	1.38%
Zebra Finch	Taeniopygia guttata	131	45.33%
Australasian Pipit	Anthus novaeseelandiae	34	11.76%
Horsfield's Bushlark	Mirafra javanica	5	1.73%
Brown Songlark	Cincloramphus cruralis	2	0.69%
Rufous Songlark	Cincloramphus mathewsi	13	4.50%

Common Name	Scientific Name	Count	Reporting Rate
Spinifexbird	Poodytes carteri	29	10.03%
Australian Reed-Warbler	Acrocephalus australis	2	0.69%
White-backed Swallow	Cheramoeca leucosterna	1	0.35%
Fairy Martin	Petrochelidon ariel	47	16.26%
Tree Martin	Petrochelidon nigricans	24	8.30%
Yellow White-eye	Zosterops luteus	3	1.04%
Crow & Raven spp		69	23.88%

APPENDIX G SIGNIFICANT FAUNA RECORDS. DPAW THREATENED AND PRIORITY SPECIES DATABASE (30 KM BUFFER)

Summary of conservation significant fauna records from DPAW Threatened and Priority Species Database

Common Name	Species	WA Status	EPBC Act Status	Records	Latest Record
Fork-tailed Swift	Apus pacificus	IA	IA	15	2011
Oriental Plover	Charadrius veredus	IA	IA	1	1999
Peregrine Falcon	Falco peregrinus	OS		2	2013
Grey Falcon	Falco hypoleucos	VU		3	2015
Brush-tailed Mulgara	Dasycercus blythi	P4		14	2013
Ghost Bat	Macroderma gigas	VU	VU	12	2016
Greater Bilby	Macrotis lagotis	VU	VU	12	2016
Northern Quoll	Dasyurus hallucatus	EN	EN	97	2016
Pilbara Leaf-nosed Bat	Rhinonicteris aurantia (Pilbara)	VU	VU	195	2017
Spectacled Hare-wallaby	Lagorchestes conspicillatus	P3		264	1996
Western Pebble-mound Mouse	Pseudomys chapmani	P4		33	2016
Pilbara Olive Python	Liasis olivaceus barroni	VU	VU	9	2015

APPENDIX H STUDY AREA PLANT SPECIES LIST

Family	Species
Amaranthaceae	*Alternanthera angustifolia*
	Gomphrena cunninghamii
	Ptilotus aervoides
	Ptilotus astrolasius
	Ptilotus auriculifolius
	Ptilotus calostachyus
	Ptilotus clementii
	Ptilotus fusiformis
	Ptilotus gomphrenoides
	Ptilotus nobilis
Asteraceae	*Pluchea dentex*
	Pluchea rubelliflora
	Pterocaulon sphacelatum
	Streptoglossa bubakii
Boraginaceae	*Heliotropium cunninghamii*
	Heliotropium heteranthum
Caryophyllaceae	*Polycarpaea holtzei*
Chenopodiaceae	*Salsola australis*
Cleomaceae	*Cleome uncifera*
	Cleome viscosa
Convolvulaceae	*Bonamia erecta*
	Bonamia pilbarensis
	Polymeria ambigua
Cucurbitaceae	*Cucumis variabilis*
Cyperaceae	*Bulbostylis barbata*
	Fimbristylis phaeoleuca
Euphorbiaceae	*Euphorbia australis* var. *subtomentosa*
	Euphorbia biconvexa
	Euphorbia clementii (P3)
	Euphorbia vaccaria
Fabaceae	*Acacia acradenia*
	Acacia ancistrocarpa
	Acacia bivenosa
	Acacia colei
	Acacia inaequilatera
	Acacia stellaticeps
	Acacia synchronicia
	Acacia trachycarpa
	Acacia tumida var. *pilbarensis*
	Alysicarpus muelleri
	Cajanus cinereus
	Indigofera monophylla
	Indigofera trita
	Isotropis atropurpurea
	Neptunia dimorphantha
	Petalostylis labicheoides
	Rhynchosia minima
	Senna artemisioides subsp. *oligophylla*
	Senna glutinosa subsp. *glutinosa*
	Senna notabilis
	Sesbania cannabina
	Swainsona formosa
	Tephrosia rosea var. *clementii*
	Tephrosia virens
Goodeniaceae	*Dampiera candicans*
	Goodenia lamprosperma
	Goodenia muelleriana

Family	Species
Goodeniaceae (cont.)	*Goodenia stobbsiana*
	Scaevola amblyanthera var. *centralis*
	Scaevola spinescens
Lauraceae	*Cassytha filiformis*
Malvaceae	*Abutilon macrum*
	Abutilon otocarpum
	Abutilon sp. Pilbara (W.R. Barker 2025)
	Corchorus ?walcottii
	Corchorus tridens
	Gossypium australe
	Hibiscus sturtii
	Seringia nephrosperma
	Sida ?arenicola
	Sida fibulifera
	Sida spinosa
	Triumfetta clementii
Marsileaceae	*Marsilea hirsuta*
Molluginaceae	*Trigastrotheca molluginea*
Myrtaceae	*Corymbia flavescens*
	Corymbia hamersleyana
	Eucalyptus victrix
Nyctaginaceae	*Boerhavia repleta*
Orobanchaceae	*Buchnera linearis*
Phyllanthaceae	*Notoleptopus decaisnei*
	Phyllanthus maderaspatensis
Plantaginaceae	*Stemodia grossa*
Poaceae	*Aristida contorta*
	Aristida holathera var. *holathera*
	Aristida latifolia
	Astrebla pectinata
	**Cenchrus ciliaris*
	**Cenchrus setiger*
	Chrysopogon fallax
	Cynodon convergens
	Dichanthium sericeum subsp. *humilius*
	**Echinochloa colona*
	Enneapogon caerulescens
	Enneapogon robustissimus
	Eragrostis cumingii
	Eragrostis eriopoda
	Eragrostis tenellula
	Eriachne benthamii
	Eriachne ciliata
	Eriachne mucronata
	Eriachne pulchella subsp. *dominii*
	Eulalia aurea
	Heteropogon contortus
	Iseilema vaginiflorum
	Paraneurachne muelleri
	Sporobolus australasicus
	Themeda triandra
	Triodia brizoides
	Triodia chichesterensis (P3)
	Triodia epactia
	Triodia lanigera
	Triodia longiceps
	Triodia wiseana

Family	Species
Proteaceae	*Grevillea pyramidalis*
	Grevillea wickhamii
	Hakea lorea
Rubiaceae	*Oldenlandia crouchiana*
Solanaceae	*Solanum diversiflorum*
	Solanum lasiophyllum
Violaceae	*Hybanthus aurantiacus*
Zygophyllaceae	*Tribulus hirsutus*

APPENDIX I CONSERVATION SIGNIFICANT PLANT SPECIES RECORDS

Taxon	Easting	Northing	Estimated abundance
Euphorbia clementii (P3)	695152.24	7667805.1	20
Euphorbia clementii (P3)	694979.87	7667665.6	5
Euphorbia clementii (P3)	694955.78	7667670.9	1
Euphorbia clementii (P3)	695404.25	7667830.3	4
Euphorbia clementii (P3)	694504.52	7667697.8	1
Euphorbia clementii (P3)	694839.02	7667659.3	1
Euphorbia clementii (P3)	694846.46	7667658.7	1
Euphorbia clementii (P3)	694892.18	7667661	1
Euphorbia clementii (P3)	694941.43	7667661.5	1
Euphorbia clementii (P3)	694946.59	7667661.2	1
Euphorbia clementii (P3)	694993.77	7667678.3	1
Euphorbia clementii (P3)	695096.34	7667755.8	1
Euphorbia clementii (P3)	695136.62	7667785.4	1
Euphorbia clementii (P3)	695139.65	7667791.5	1
Euphorbia clementii (P3)	695139.32	7667793.8	1
Euphorbia clementii (P3)	695141.64	7667803.4	5
Euphorbia clementii (P3)	695154.4	7667808.5	1
Euphorbia clementii (P3)	695162.83	7667814.2	12
Euphorbia clementii (P3)	695167.73	7667816.8	1
Euphorbia clementii (P3)	695171.26	7667819.5	2
Euphorbia clementii (P3)	695175.06	7667823.7	9
Euphorbia clementii (P3)	695189.42	7667840	50
Euphorbia clementii (P3)	695208.68	7667855.2	25
Euphorbia clementii (P3)	695231.48	7667875.7	50
Euphorbia clementii (P3)	695262.15	7667901.6	50
Euphorbia clementii (P3)	694145.52	7667665.7	1
Euphorbia clementii (P3)	693851.53	7667636.1	1
Triodia chichesterensis (P3) (population centroid)	695459.5	7668279	1000+

APPENDIX J FLORA SITE DATA

Site	Date	Easting	Northing	Landform	Slope	Soil Colour	Soil Type	Main Rock Type	Rock Size	Rock Abundance	Vegetation Condition	Disturbance Type	Leaf Litter
1	14/05/2018	694675.12	7668467.3	Minor Creek (< 5 m)	Negligible	Orange	Clay Loam			No Rocks	Good	Weeds, grazing	< 10%
2	14/05/2018	694494.98	7668423.9	Minor Creek (< 5 m)	Negligible	Orange	Clay Loam	Quartz, granite	Pebbles (2-64 mm)	< 10%	Very Good	Weeds	< 10%
3	14/05/2018	694504.5	7668314.4	Gilgai/Cracking clay	Negligible	Orange	Clay			No Rocks	Very Good	Weeds, grazing	< 10%
4	14/05/2018	694467.03	7668143.5	Drainage/Floodplain	Negligible	Orange	Clay Loam	Quartz, granite	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
5	14/05/2018	694460.49	7668025.7	Gilgai/Cracking clay	Negligible	Orange	Clay	Ironstone, quartz	Pebbles (2-64 mm)	< 10%	Excellent	None obvious	< 10%
6	14/05/2018	694503.22	7667605	Drainage Line	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
7	14/05/2018	694157.91	7667609.8	Drainage Line	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
8	14/05/2018	694193.26	7667983.3	Undulating Plain	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
9	15/05/2018	694197.07	7668462.1	Minor Creek (< 5 m)	Negligible	Orange	Clay Loam			No Rocks	Very Good	Weeds, grazing	10-40%
10	15/05/2018	694129.34	7668617.3	Drainage Line	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
11	15/05/2018	694131.88	7668723.9	Undulating Plain	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
12	15/05/2018	694180.55	7668971.7	Gilgai/Cracking clay	Negligible	Orange	Clay	Ironstone, quartz	Pebbles (2-64 mm)	< 10%	Excellent	None obvious	< 10%
13	15/05/2018	694073.03	7669164.2	Undulating Plain	Negligible	Orange	Clay Loam	Mixed	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
14	15/05/2018	694416.13	7669256.7	Undulating Plain	Negligible	Orange	Clay Loam	Mixed	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
15	15/05/2018	694603.68	7668921	Undulating Plain	Negligible	Orange	Clay Loam	Mixed		30-70%	Excellent	None obvious	< 10%
16	15/05/2018	694610.63	7668860.9	Drainage Line	Negligible	Orange	Clay Loam	Mixed	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
17	15/05/2018	694936.99	7668506.8	Minor Creek (< 5 m)	Negligible	Orange	Clay Loam			No Rocks	Very Good	Weeds	< 10%
18	15/05/2018	695370.58	7668589.4	Drainage/Floodplain	Negligible	Orange	Clay Loam			No Rocks	Very Good	Weeds, grazing	< 10%
19	15/05/2018	695586.34	7668620.7	Undulating Plain	Negligible	Orange	Clay Loam	Quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
20	15/05/2018	695548.35	7668366.3	Drainage/Floodplain	Negligible	Orange	Clay Loam			No Rocks	Very Good	Weeds, grazing	< 10%
21	15/05/2018	695490.71	7668288.5	Undulating Plain	Negligible	Orange	Clay Loam	Quartz, granite	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
22	15/05/2018	694893.82	7668451.3	Drainage/Floodplain	Negligible	Orange	Sandy Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	10-30%	Very Good	Grazing	< 10%
23	15/05/2018	695208.8	7667641.3	Undulating Plain	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
24	16/05/2018	695233.89	7667623.1	Gilgai/Cracking clay	Negligible	Orange	Clay	Ironstone, quartz	Pebbles (2-64 mm)	< 10%	Very Good	Grazing	< 10%
25	16/05/2018	695360.78	7667937.5	Undulating Plain	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
26	16/05/2018	695291.49	7668099	Undulating Plain	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
27	16/05/2018	695258.02	7668153.3	Undulating Plain	Negligible	Orange	Clay Loam	Quartz, granite	Pebbles (2-64 mm)	30-70%	Excellent	None obvious	< 10%
28	16/05/2018	695164.62	7668168.5	Minor Creek (< 5 m)	Negligible	Orange	Clay Loam	Granite, ironstone, quartz	Pebbles (2-64 mm)	< 10%	Excellent	None obvious	< 10%

Site	Record	Name	Stratum	Cover %
1	1	*Eucalyptus victrix*	Tree (10-30 m)	5
1	2	*Corymbia hamersleyana*	Tree (<10 m)	5
1	3	*Triodia epactia*	Hummock Grass	10
1	4	*Acacia colei*	Shrub (>2 m)	1
1	5	*Themeda triandra*	Grass	1
1	6	*Cenchrus ciliaris*	Grass	5
1	7	*Corchorus ?walcottii*	Shrub (0-1 m)	1
2	1	*Corymbia hamersleyana*	Tree (<10 m)	2
2	2	*Acacia ancistrocarpa*	Shrub (>2 m)	2
2	3	*Acacia stellaticeps*	Shrub (1-2 m)	2
2	4	*Acacia bivenosa*	Shrub (1-2 m)	2
2	5	*Corchorus ?walcottii*	Shrub (0-1 m)	1
2	6	*Triodia epactia*	Hummock Grass	20
2	7	*Triodia longiceps*	Hummock Grass	20
2	8	*Triodia wiseana*	Hummock Grass	5
3	1	*Chrysopogon fallax*	Grass	50
3	2	*Triodia epactia*	Hummock Grass	5
3	3	*Sida fibulifera*	Herb	2
3	4	*Eriachne benthamii*	Grass	20
4	1	*Acacia ancistrocarpa*	Shrub (1-2 m)	5
4	2	*Triodia epactia*	Hummock Grass	10
4	3	*Triodia lanigera*	Hummock Grass	40
4	4	*Triodia brizoides*	Hummock Grass	40
5	1	*Sida fibulifera*	Herb	10
5	2	*Neptunia dimorphantha*	Herb	10
5	3	*Sporobolus australasicus*	Grass	5
5	4	*Cynodon convergens*	Grass	20
5	5	*Eriachne benthamii*	Grass	10
6	1	*Acacia acradenia*	Shrub (>2 m)	20
6	2	*Petalostylis labicheoides*	Shrub (>2 m)	10
6	3	*Triodia epactia*	Hummock Grass	20
6	4	*Corchorus ?walcottii*	Shrub (0-1 m)	5
6	5	*Chrysopogon fallax*	Grass	2
6	6	*Indigofera monophylla*	Shrub (0-1 m)	1
6	7	*Acacia tumida*	Shrub (>2 m)	2
7	1	*Acacia tumida*	Shrub (1-2 m)	10
7	2	*Petalostylis labicheoides*	Shrub (1-2 m)	10
7	3	*Acacia acradenia*	Shrub (1-2 m)	5
7	4	*Triodia epactia*	Hummock Grass	20
7	5	*Triodia lanigera*	Hummock Grass	5
7	6	*Indigofera monophylla*	Shrub (0-1 m)	2
7	7	*Corchorus ?walcottii*	Shrub (0-1 m)	2
8	1	*Acacia bivenosa*	Shrub (1-2 m)	1
8	2	*Triodia brizoides*	Hummock Grass	60
8	3	*Triodia longiceps*	Hummock Grass	10
8	4	*Acacia ancistrocarpa*	Shrub (1-2 m)	1
8	5	*Acacia inaequilatera*	Shrub (1-2 m)	1
9	1	*Corymbia hamersleyana*	Tree (<10 m)	5
9	2	*Acacia acradenia*	Shrub (>2 m)	10
9	3	*Acacia ancistrocarpa*	Shrub (>2 m)	5
9	4	*Triodia epactia*	Hummock Grass	10
9	5	*Themeda triandra*	Hummock Grass	40
9	6	*Corchorus ?walcottii*	Shrub (0-1 m)	5
10	1	*Acacia ancistrocarpa*	Shrub (1-2 m)	15
10	2	*Acacia inaequilatera*	Shrub (>2 m)	5
10	3	*Acacia bivenosa*	Shrub (1-2 m)	5
10	4	*Triodia epactia*	Hummock Grass	60
10	5	*Corymbia hamersleyana*	Tree (<10 m)	1

Site	Record	Name	Stratum	Cover %
10	6	*Acacia acradenia*	Shrub (1-2 m)	5
11	1	*Corymbia hamersleyana*	Tree (<10 m)	1
11	2	*Acacia inaequilatera*	Shrub (>2 m)	1
11	3	*Acacia acradenia*	Shrub (0-1 m)	1
11	4	*Triodia lanigera*	Hummock Grass	50
12	1	*Eriachne benthamii*	Grass	40
12	2	*Chrysopogon fallax*	Grass	5
12	3	*Neptunia dimorphantha*	Herb	5
12	4	*Cynodon convergens*	Grass	5
12	5	*Sida fibulifera*	Herb	5
12	6	*Rhychosia minima*	Herb	5
13	1	*Acacia inaequilatera*	Shrub (>2 m)	1
13	2	*Acacia ancistrocarpa*	Shrub (1-2 m)	1
13	3	*Triodia epactia*	Hummock Grass	50
13	4	*Triodia longiceps*	Hummock Grass	20
14	1	*Triodia longiceps*	Hummock Grass	60
14	2	*Acacia acradenia*	Shrub (1-2 m)	1
14	3	*Acacia ancistrocarpa*	Shrub (1-2 m)	1
14	4	*Triodia epactia*	Hummock Grass	5
14	5	*Acacia bivenosa*	Shrub (1-2 m)	1
16	1	*Acacia acradenia*	Shrub (1-2 m)	5
16	2	*Acacia ancistrocarpa*	Shrub (1-2 m)	5
16	3	*Petalostylis labicheoides*	Shrub (1-2 m)	5
16	4	*Triodia epactia*	Hummock Grass	60
16	5	*Triodia wiseana*	Hummock Grass	10
17	1	*Corymbia hamersleyana*	Tree (<10 m)	5
17	2	*Acacia acradenia*	Shrub (1-2 m)	10
17	3	*Petalostylis labicheoides*	Shrub (1-2 m)	10
17	4	*Triodia epactia*	Hummock Grass	20
17	5	*Themeda triandra*	Grass	10
17	6	*Chrysopogon fallax*	Grass	5
18	1	*Corymbia hamersleyana*	Tree (<10 m)	2
18	2	*Acacia inaequilatera*	Shrub (>2 m)	2
18	3	*Themeda triandra*	Grass	30
18	4	*Chrysopogon fallax*	Grass	20
18	5	*Acacia acradenia*	Shrub (>2 m)	5
18	6	*Triodia epactia*	Hummock Grass	5
19	1	*Acacia inaequilatera*	Shrub (>2 m)	1
19	2	*Acacia ancistrocarpa*	Shrub (>2 m)	1
19	3	*Triodia longiceps*	Hummock Grass	50
19	4	*Triodia epactia*	Hummock Grass	5
21	1	*Acacia inaequilatera*	Shrub (>2 m)	1
21	2	*Acacia acradenia*	Shrub (>2 m)	2
21	3	*Triodia chichesterensis* (P3)	Hummock Grass	40
22	1	*Corymbia hamersleyana*	Tree (<10 m)	1
22	2	*Acacia inaequilatera*	Shrub (1-2 m)	5
22	3	*Acacia acradenia*	Shrub (1-2 m)	5
22	4	*Acacia ancistrocarpa*	Shrub (1-2 m)	5
22	5	*Triodia epactia*	Hummock Grass	40
22	6	*Petalostylis labicheoides*	Shrub (1-2 m)	5
23	1	*Triodia longiceps*	Hummock Grass	70
23	2	*Acacia inaequilatera*	Shrub (>2 m)	1
24	1	*Acacia synchronicia*	Shrub (>2 m)	5
24	2	*Eriachne benthamii*	Grass	10
24	3	*Cynodon convergens*	Grass	10
24	4	*Sporobolus australasicus*	Grass	5
24	5	*Sida fibulifera*	Herb	5
24	6	*Neptunia dimorphantha*	Herb	20

Site	Record	Name	Stratum	Cover %
25	1	*Acacia ancistrocarpa*	Shrub (1-2 m)	20
25	2	*Acacia acradenia*	Shrub (1-2 m)	5
25	3	*Petalostylis labicheoides*	Shrub (1-2 m)	5
25	4	*Triodia epactia*	Hummock Grass	50
25	5	*Triodia wiseana*	Hummock Grass	10
28	1	*Corymbia hamersleyana*	Tree (<10 m)	2
28	2	*Acacia acradenia*	Shrub (>2 m)	10
28	3	*Acacia ancistrocarpa*	Shrub (>2 m)	10
28	4	*Triodia epactia*	Hummock Grass	30
28	5	*Triodia wiseana*	Hummock Grass	20
28	6	*Grevillea wickhamii*	Shrub (>2 m)	2

APPENDIX K FAUNA SURVEY TRACK LOGS

7668000

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- Disused Western Pebble-mound Mouse Mound
- Fauna Habitat Sites
- 1739_TM_Tracks

Habitat Type

- Minor Drainage Line
- Stony Plains
- M45/1260 study area

ecologia ENVIRONMENT

Drawn: TM Project ID: 1739
Date: 6 June 2018 A3

N

0 0.075 0.15
Kilometers
Scale: 1:7,923
MGA94 (Zone 50)

Fauna Track Log

Figure:
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APPENDIX L FAUNA HABITAT ASSESSMENT SHEETS

Site	Landform		Condition	Habitat
S01	Drainage tract and Minor Channel		Good	Minor Drainage line
Description	Minor sandy drainage line			
% Ground Cover	Bare Soil	40%		
	Litter	Minor		
	Canopy Cover	15%		
	Understorey	50%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay loams		
	Colour	Red		
Habitat Features	Water Impacts	Eroded banks	**Vegetation**	
	Fire Presence	>5 years	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	Minor	Upper	Tree	>10m	*Eucalyptus victrix and Corymbia hamersleyana*
	Grazing	Present				
	Rock Crevices	None	Middle	Shrubs	<3m	*Acacia colei*
	Burrowing Suitability	Moderate				
	Large trees present	Yes	Ground	Grasses	0.5m	*Triodia epactia* hummock grassland
	Tree Hollows (>10cm)	Few				

Site	Landform		Condition	Habitat
S02	Drainage tract		Very Good	Minor drainage line
Description	Open Corymbia over relatively dense acacias with thick understory of spinifex and grasses			
% Ground Cover	Bare Soil	10%		
	Litter	Minor		
	Canopy Cover	10%		
	Understorey	90%		
Rocks	No exposed rock			
	<20% exposed rock	X		
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay-Loam		
	Colour	Red		
Habitat Features	Water Impacts	Drainage	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	Minor	Upper	Tree	<10m	*Corymbia hamersleyana*
	Grazing	Present				
	Rock Crevices	None	Middle	Shrub	1.5m	Scattered *Acacia colei*
	Burrowing Suitability	Moderate				
	Large trees present	Yes	Ground	Grasses	0.75m	*Triodia wiseana* and *Triodia* epactia hummock grassland
	Tree Hollows (>10cm)	no				

Site	Landform		Condition	Habitat
S03	Plain		Excellent	Stony Plains
Description	Expansive stony plains of scattered acacia over spinifex.			
% Ground Cover	Bare Soil	15%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay Loam		
	Colour	Red		
Habitat Features	Water Impacts	None	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	Minor	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	1.5m	Scattered *Acacia stellaticeps and Acacia tumida*
	Burrowing Suitability	Low				
	Large trees present	No	Ground	Grasses	0.5m	*Triodia longiceps* and *Triodia* sp. hummock grassland
	Tree Hollows (>10cm)	No				

Site	Landform		Condition			Habitat
S04	Plain		Excellent			Stony Plains
Description	Expansive stony plains of scattered acacia over spinifex.					
% Ground Cover	Bare Soil	Minor				
	Litter	None				
	Canopy Cover	None				
	Understorey	50%				
Rocks	No exposed rock	X				
	<20% exposed rock					
	20-50% exposed rock					
	>50% exposed rock					
	Boulders / Rocks %					
Soil	Type	Clay loam				
	Colour	Red				
Habitat Features	Water Impacts	None	**Vegetation**			
	Fire Presence	Long unburnt	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	1.5m	Scattered *Acacia inaequilatera and Acacia tumida*
	Burrowing Suitability	Low				
	Large trees present	No	Ground	Grasses	0.5m	*Triodia longiceps* and *Triodia* sp. hummock grassland
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S05	Plain		Excellent	Stony Plains
Description	Open hummock grasslands and Gilgai claypans			
% Ground Cover	Bare Soil	10%		
	Litter	None		
	Canopy Cover	None		
	Understorey	90%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay Loam		
	Colour	Red		
Habitat Features	Water Impacts	Pooling	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**
	Woody Debris	None	Upper	None
	Grazing	Minor		
	Rock Crevices	None	Middle	None
	Burrowing Suitability	Moderate		
	Large trees present	No	Ground	Grasses
	Tree Hollows (>10cm)	No		

Height	**Species**
0.75m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands and Gilgai*

Site	Landform		Condition	Habitat
S06	Undulating Plain		Excellent	Stoney Plain
Description	Expansive stony plains of Scattered acacia over spinifex.			
% Ground Cover	Bare Soil	30%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay-Loam		
	Colour	Red		
Habitat Features	Water Impacts	None	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	2m	Scattered *Acacia tumida and A inaequilatera*
	Burrowing Suitability	Low				
	Large trees present	No	Ground	Grasses	0.75m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S07	Undulating Plains		Excellent	Stony Plains
Description	Expansive stony plains of scattered Acacia over spinifex intersected with very minor drainage lines			
% Ground Cover	Bare Soil	30%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Loam		
	Colour	Red		
Habitat Features	Water Impacts	Minor sheet erosion	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	None	2m	Scattered *Acacia ancistrocarpa* and *Acacia* tumida
	Burrowing Suitability	Moderate				
	Large trees present	No	Ground	Grasses	0.5m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S08	Plains		Very Good	Stony Plains
Description	Tall open Acacias over spinifex			
% Ground Cover	Bare Soil	10%		
	Litter	Moderate		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay loam		
	Colour	Red		
Habitat Features	Water Impacts	None	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	Minor	Upper	None		
	Grazing	Minor				
	Rock Crevices	None	Middle	None	2m	Acacia spp. (A. acradenia, A. ancistrocarpa, A. tumida) tall open shrubland
	Burrowing Suitability	Moderate				
	Large trees present	No	Ground	Grasses	0.5m	Triodia epactia hummock grassland
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S09	Plain		Excellent	Stony Plain
Description	Scattered Acacias over spinifex with very minor drainage line			
% Ground Cover	Bare Soil	30%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Loam		
	Colour	Red		
Habitat Features	Water Impacts	Minor Drainage	**Vegetation**	
	Fire Presence	>5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	2m	*Scattered Acacia acradenia, A. ancistrocarpa, A. tumida*
	Burrowing Suitability	Moderate				
	Large trees present	No	Ground	Grasses	0.75m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S10	Undulating Plains		Excellent	Stony Plain
Description	Expansive stony plains of Scattered acacia over spinifex.			
% Ground Cover	Bare Soil	40%		
	Litter	None		
	Canopy Cover	None		
	Understorey	60%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay-Loam		
	Colour	Red		
Habitat Features	Water Impacts	None	**Vegetation**	
	Fire Presence	>5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper			
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	2m	*Scattered Acacia acradenia, A. ancistrocarpa, A. tumida*
	Burrowing Suitability	Minor				
	Large trees present	No	Ground	Grasses	0.75m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S11	Undulating Plain		Very Good	Stoney Plain
Description	Tall open acacia shrubland over spinifex			
% Ground Cover	Bare Soil	10%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	85%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay-Loam		
	Colour	Red		
Habitat Features	Water Impacts	Pooling		
	Fire Presence	> 5 yrs		
	Woody Debris	Minor		
	Grazing	Minor		
	Rock Crevices	None		
	Burrowing Suitability	Moderate		
	Large trees present	No		
	Tree Hollows (>10cm)	No		



Vegetation			
Stratum	**Form**	**Height**	**Species**
Upper	None		
Middle	Tall Shrub	>3m	*Acacia tumida, A acradenia, A ancistrocarpa*
Ground	Grasses	0.5m	*Triodia lanigera* hummock grassland, Eriachne sp

Site	Landform		Condition	Habitat
S12	Plains		Excellent	Stony Plains
Description	Expansive stony plains of scattered acacia over spinifex with occasional Gilgai claypans.			
% Ground Cover	Bare Soil	30%		
	Litter	None		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay-Loam		
	Colour	Red		
Habitat Features	Water Impacts	Claypans	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	None	Upper	None		
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	1.5m	Scattered *Acacia acradenia* and *Acacia inaequilatera*
	Burrowing Suitability	Minor				
	Large trees present	No	Ground	Grasses	0.5m	*Triodia longiceps (+/- T. lanigera, T. brizoides) open hummock grasslands*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S13	Drainage tract		Excellent	Minor Drainage line
Description	Minor sandy drainage line of sparse Corymbia above thick acacias over spinifex			
% Ground Cover	Bare Soil	10%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	70%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Shallow Loam		
	Colour	Red		
Habitat Features	Water Impacts	Minor drainage line	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**
	Woody Debris	Minor	Upper	Tree
	Grazing	None		
	Rock Crevices	None	Middle	Shrub
	Burrowing Suitability	Moderate		
	Large trees present	Yes	Ground	Grasses
	Tree Hollows (>10cm)	No		

Height	Species
<10m	*Corymbia Hamersleyana*
1.5m	*Acacia acradenia, A. ancistrocarpa, A. tumida*
0.5m	*Triodia epactia*

Site	Landform		Condition	Habitat
S14	Drainage tract		Excellent	Minor Drainage line
Description	Minor sandy drainage line of sparse Corymbia above thick acacias over spinifex			
% Ground Cover	Bare Soil	10%		
	Litter	Minor		
	Canopy Cover	None		
	Understorey	85%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Shallow Loam		
	Colour	Red		
Habitat Features	Water Impacts	Minor drainage	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**	**Height**	**Species**
	Woody Debris	Minor	Upper	Tree	<10m	*Corymbia Hamersleyana*
	Grazing	None				
	Rock Crevices	None	Middle	Shrub	1.5m	*Acacia acradenia, A. ancistrocarpa, A. tumida, A inaequilatera*
	Burrowing Suitability	Moderate				
	Large trees present	Yes	Ground	Grasses	0.5m	*Triodia epactia*
	Tree Hollows (>10cm)	No				

Site	Landform		Condition	Habitat
S15	Undulating Plain		Excellent	Stoney Plain
Description	Expansive stony plains of scattered acacia over spinifex with occasional Gilgai claypans.			
% Ground Cover	Bare Soil	40%		
	Litter	None		
	Canopy Cover	None		
	Understorey	60%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay Loam		
	Colour	Red		
Habitat Features	Water Impacts	Sheet runoff	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**
	Woody Debris	None	Upper	
	Grazing	None		
	Rock Crevices	None	Middle	Shrub
	Burrowing Suitability	Moderate		
	Large trees present	No	Ground	Grasses
	Tree Hollows (>10cm)	No		

Height	**Species**
1.5m	*Acacia acradenia, A. ancistrocarpa, A. tumida*
0.5m	*Triodia longiceps (+/- T. lanigera, T. brizoides)*

Site	Landform		Condition	Habitat
S16	Drainage tract		Poor	Minor Dainage Line
Description	Sandy floodplain of scattered Corymbia sparse acacias and scattered spinifex.			
% Ground Cover	Bare Soil	90%		
	Litter	Minor		
	Canopy Cover	<5%		
	Understorey	10%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay Loam		
	Colour	Red/Brown		
Habitat Features	Water Impacts	Sheet runoff	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**
	Woody Debris	Minor	Upper	Tree
	Grazing	Heavy		
	Rock Crevices	None	Middle	Shrub
	Burrowing Suitability	Moderate		
	Large trees present	Yes	Ground	Grasses
	Tree Hollows (>10cm)	No		

Height	**Species**
<10m	*Corymbia Hamersleyana*
1.5m	*Acacia inaequilatera, A ancistrocarpa*
0.5m	*Triodia epactia and T wiseana, Buffel grass (Cenchrus ciliaris)*

Site	Landform		Condition	Habitat
S17	Undulating Plain		Excellent	Stony Plain
Description	Expansive stony plains of scattered Acacia over spinifex intersected with very minor drainage lines			
% Ground Cover	Bare Soil	25%		
	Litter	None		
	Canopy Cover	None		
	Understorey	75%		
Rocks	No exposed rock	X		
	<20% exposed rock			
	20-50% exposed rock			
	>50% exposed rock			
	Boulders / Rocks %			
Soil	Type	Clay Loam		
	Colour	Red		
Habitat Features	Water Impacts	Very Minor drainage	**Vegetation**	
	Fire Presence	> 5 yrs	**Stratum**	**Form**
	Woody Debris	None	Upper	
	Grazing	None		
	Rock Crevices	None	Middle	Shrub
	Burrowing Suitability	Minor		
	Large trees present	No	Ground	Grasses
	Tree Hollows (>10cm)	No		

Height	**Species**
1.5m	*Acacia acradenia, A. ancistrocarpa, A. tumida*
0.5m	*Triodia longiceps (+/- T. lanigera, T. brizoides)*

APPENDIX 3 – ANIMAL PLANT MINERAL BIOLOGICAL SURVEY REPORT

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TSF Options 2 and 5

Pilgangoora Project

Biological Survey

Pilbara, Western Australia

Prepared for
Pilbara Minerals Limited by
Animal Plant Mineral Pty Ltd.

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EXECUTIVE SUMMARY

Animal Plant Mineral Pty Ltd was commissioned by Pilbara Minerals Limited to undertake a Detailed flora and vegetation and Targeted terrestrial vertebrate fauna survey of the Tailings Storage Facility (**TSF**) Options 2 and 5 areas. The TSF Options 2 and 5 areas are considered for additional tailings storage capacity, or other purposes, at the Pilgangoora Lithium Project, located 84 kilometres (**km**) south-east of Port Hedland in the Pilbara region of Western Australia (**WA)**. Option 2 is 354 hectares (**ha**) (2 km x 1.6 km) and Option 5 is 329 ha (1.8 km x 1.8 km).

Field survey was conducted in October 2022. The rainfall in Winter/Spring preceding the survey was approximately double the average for the period. The higher-than-average winter rainfall is a result of a high total monthly rainfall in May of 123.8 millimetres (**mm**), which is almost 4.5 times higher than the long-term average of 52.3 mm for the same period. No adverse weather conditions occurred that would impact the results of the survey. The timing of the flora and vegetation survey was outside of the recommended Supplementary survey period for the region, however seasonal conditions were good following a wetter than average winter. Survey timing was within that recommended for mammals and reptiles (EPA 2020).

Three vegetation types are described for the Study Areas and are different to those described during baseline surveys for the Pilgangoora Project. No vegetation of conservation significance was recorded, and current extent of regional vegetation units is close to pre-European extent. Vegetation is predominantly in very good condition with the main disturbances being moderate to high cattle grazing and vegetation clearing for mining and pastoral activity. Completely Degraded areas comprise 10.4 ha or 2.9% of the TSF Option 2, and 12.8 ha or 3.9% of TSF Option 5.

No Threatened or Priority flora are known to occur in the Study areas or were recorded during the survey. Nine Priority flora species identified in the desktop study possibly occur, due to the presence of suitable habitat. Seasonal conditions may be a constraint on the detectability of seven annual/herbaceous Priority flora that possibly occur.

No Declared weeds or Weeds of National Significance were recorded. Six weeds were recorded - *Cenchrus ciliaris, Cenchrus setiger, Flaveria trinervia, Malvastrum americanum, Triumfetta pentandra* and *Aerva javanica.*

Two fauna habitats are described for the Study Areas:

- FH1 – Undulating plains (78.2% of Option 2, 89.2% of Option 5); and
- FH2 – Ephemeral creeks (18.9% of Option 2, 6.9% of Option 5).

No Threatened or Priority fauna species are known to occur in the Study Areas. Database records from the local area indicate that 15 conservation significant fauna may possibly occur or are likely to occur.

Targeted survey for conservation significant fauna identified:

- Western pebble-mound mouse is present and 13 mound locations recorded;
- Foraging habitat suitable for the Grey falcon occurs and may be used by local populations;
- Foraging and dispersal habitat suitable for the Northern quoll occurs, but no evidence of presence was recorded, despite critical habitat known to occur 4 km to the west; and

- Possible habitat for the Night parrot, Greater bilby, Brush-tailed mulgara, and Ghost bat, but no evidence of their presence was recorded.

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PROJECT TERMS

Abbreviation	Meaning
The Project	Pilgangoora Lithium Project
TSF	Tailings Storage Facility

UNITS OF MEASURE

Unit	Measure
%	Percentage
°C	Degrees Celsius
ha	Hectare
km	Kilometre
m	Metre
mm	Millimetre

LIST OF ABBREVIATIONS

Abbreviation	Meaning
APM	Animal Plant Mineral Pty Ltd
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BC Act	*Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
DBCA	Department of Biological Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEE	Department of Energy and the Environment
DMIRS	Department of Mines, Industry Regulation and Safety
DWER	Department of Water and Environment Regulation
DPIRD	Department of Primary Industries and Regional Development
EN	Endangered
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESA	Environmentally Sensitive Areas
IBRA	Interim Biogeographic Regionalisation for Australia
IBSA	Index of Biodiversity Surveys for Assessment
MI	Migratory
MNES	Matters of National Environmental Significance
OS	Other Specifically Protected
PEC	Priority Ecological Community
P	Priority
PMST	Protected Matters Search Tool

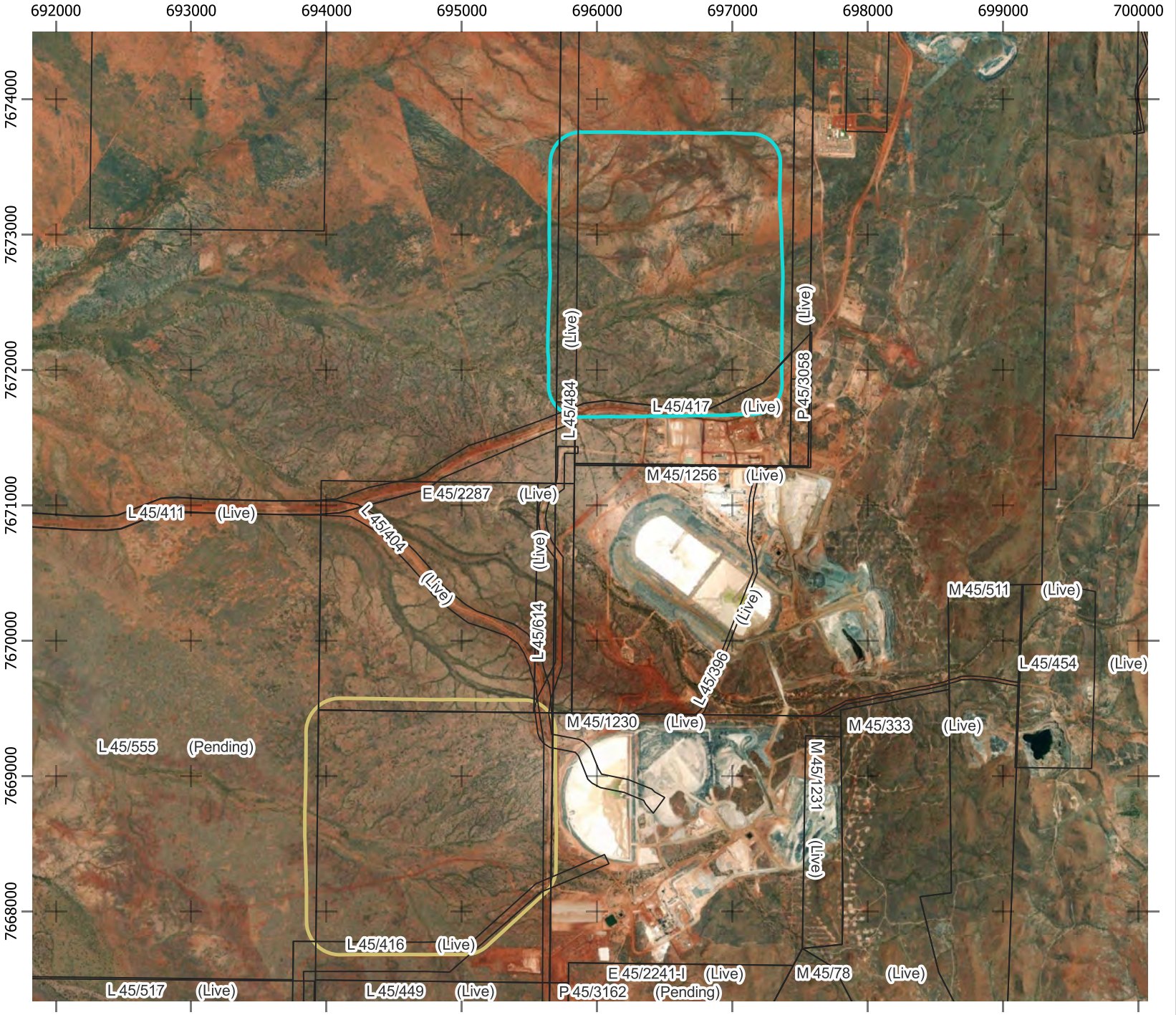
Abbreviation	Meaning
TEC	Threatened Ecological Community
T	Threatened
VU	Vulnerable
WA	Western Australia
WONS	Weeds of National Significance

1 INTRODUCTION

1.1 PROJECT AND LOCATION

Animal Plant Mineral Pty Ltd (**APM**) was commissioned by Pilbara Minerals Limited to undertake a Detailed flora and vegetation and Targeted terrestrial vertebrate fauna survey of the Tailings Storage Facility (**TSF**) Options 2 and 5 areas. The TSF Options 2 and 5 areas are considered for additional tailings storage capacity, or other potential expansions, at the Pilgangoora Lithium Project, located 84 kilometres (**km**) south-east of Port Hedland in the Pilbara region of Western Australia (**WA**).

Option 2 is 354 hectares (**ha**), measuring 2 km by 1.6 km. Option 5 is 329 ha, measuring 1.8 km by 1.8 km. Collectively they are referred to as the Study Areas and are shown in Figure 1-1.



Legend

- Pilgangoora Project Tenements
- TSF Option 2
- TSF Option 5



Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 31/10/2022

Project Location

Prepared for:
Pilbara Minerals

Figure: 1-1

1.2 SCOPE OF WORK

The scope of work includes a Detailed flora and vegetation and Targeted terrestrial vertebrate fauna survey of the TSF Options 2 and 5 areas.

Survey data accompanies this report in a format suitable for submission to the Index of Biodiversity Surveys for Assessment (**IBSA**) online portal.

1.2.1 Flora and Vegetation

The flora and vegetation survey was conducted in accordance with the Environmental Protection Authority's (**EPA**) *Technical Guidance - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment* (2016) at a Detailed level of assessment.

The aims of the desktop study were to:

- Establish vegetation associations previously determined for the site;
- Identify threatened (**T**) and priority (**P**) flora and threatened ecological communities (**TECs**) previously recorded on site;
- Identify weed species previously determined as present on site, in particular any Declared weeds; and
- Identify potentially suitable habitat for conservation significant flora known from the region.

The aims of the field survey were to:

- Determine vegetation associations on the site;
- Identify species present on site including T and P Flora;
- Locate and identify, as far as possible, weed species, in particular any Declared weeds;
- Map the vegetation and locations of T and P species; and
- Identify conservation significant features of the flora and vegetation.

1.2.2 Terrestrial Fauna

The scope of work was to conduct a basic and targeted terrestrial vertebrate survey in accordance with the EPA's fauna guidelines: *Technical Guidance – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (2020).

The aims of the desktop study were to:

- Identify species previously determined as present on-site including T and P Fauna (under the provisions of the *Biodiversity Conservation Act 2016* (**BC Act**) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**);
- Identify habitat types previously determined as present on site regarded as suitable for T and P fauna; and
- Identify introduced species previously determined as present on site.

The aims of the field survey were to conduct:

- Targeted quoll survey using unbaited camera traps;

- Bat survey using acoustic monitoring devices;
- Record incidental fauna observations;
- Conduct spotlight survey, without physical capture/collection of individuals; and
- Record habitats suitable for T and P fauna.

2 BACKGROUND AND SUPPORTING INFORMATION

2.1 RELEVANT LEGISLATION

2.1.1 Commonwealth Government EPBC Act

The Commonwealth EPBC Act is administered by the Department of Climate Change, Energy, the Environment and Water (**DCCEEW**). It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, defined in the EPBC Act as Matters of National Environmental Significance (**MNES**).

If a project has the potential to significantly impact on MNES it is to be referred to the DCCEEW for determination on whether the matter is a 'controlled action' and therefore requiring assessment.

The EPBC Act provides for the identification and listing of species under several categories listed in Appendix A. The EPBC Act also provides for the development of conservation advice and recovery plans, development of a register of critical habitat, recognition of key threatening processes and the development of threat abatement plans.

2.1.2 Western Australia BC Act

The BC Act provides a statutory basis for the listing of T species, specially protected species, extinct species, TECs, collapsed ecological communities, critical habitat and key threatening processes in WA. The BC Act provides for the listing of T flora and fauna species and ecological communities under specified conservation categories listed in Appendix A. Species and communities listed under the BC Act are protected and require authorisation by the Minister to take or disturb.

Species may also be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest to science. Species of special conservation interest, migratory species and species subject to international agreements are known as Specially Protected Species in the BC Act.

2.1.3 Western Australia Priority species and communities

Flora and fauna species and communities are listed by the Department of Biodiversity, Conservation and Attractions (**DBCA**) as P where they are considered to have a greater level of significance than other native species and communities. This generally occurs where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to T species and communities categories. Whilst P species and communities are not specifically listed in the BC Act, all flora and fauna are protected in WA following the provisions in Part 10 of the BC Act. This protection applies even when a species is not listed as T or specially protected. The categories covering P species and communities are listed in Appendix A.

2.1.4 BAM Act

Plants may be 'Declared' by the Agriculture Protection Board under the *Biosecurity and Agriculture Management Act 2007* (WA) (**BAM Act**). Declared Plants are gazetted under three categories (C1-C3) which define the action required. Details of the definitions of these categories are provided in Appendix

A. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is 'Declared', landholders are obliged to control that plant on their properties.

2.1.5 Weeds of National Significance

The DCCEEW, along with the State and Territory governments, has endorsed 32 Weeds of National Significance (**WONS**). Four major criteria were used in determining WONS:

- The invasiveness of a weed species;
- A weed's impact;
- The potential for spread of a weed; and
- Socio-economic and environmental values.

Each WONS has a national strategy and a national coordinator, responsible for implementing the strategy. WONS are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts (DAWE 2020).

2.1.6 Guidelines

The terrestrial biological assessment was conducted in accordance with the above Commonwealth and State legislation, as well as EPA requirements for environmental surveys as outlined below:

- Technical Guidance: Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA 2020a); and
- Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016).

Relevant species-specific survey and assessment guidelines include:

- Survey Guidelines for Australia's T Bats (Department of the Environment Water Heritage and the Art (**DEWHA**) 2010a).
- Survey Guidelines for Australia's T Birds (DEWHA 2010b);
- Survey Guidelines for Australia's T Mammals (Department of Sustainability Environment Water Population and Communities (**DSEWPAC**) 2011a); and
- Survey Guidelines for Australia's T Reptiles (DSEWPAC 2011b).

Relevant guidance for the preparation of spatial datasets to accompany this report are:

- Guidelines for biological survey and mapped data (Department of the Environment and Energy (**DEE**) 2018); and
- Instructions for the preparation of data packages for IBSA (EPA 2020b).

2.2 LAND USE

The majority of the Study Areas lie within the Wallareenya pastoral lease (N050365). The current land use is cattle grazing.

Active mining operations and exploration activities occur within the Pilgangoora Lithium project, east of the Study Areas.

2.3 CLIMATE

The Pilbara has very hot summers, mild winters and low and variable rainfall. It is classified as hot desert in northern and inland areas and hot grasslands in the north-west. The climate of the Chichester subregion of the Pilbara is described as semi-desert-tropical, receiving 300 millimetres (**mm**) of rainfall annually (Kendrick and McKenzie, 2001).

The nearest Bureau of Meteorology (**BoM**) weather station with a long historical record is at Port Hedland Airport (BoM Site Number: 004032), approximately 75 km northeast of the Study Areas. Port Hedland Airport has recorded rainfall from 1942 – 2022 (80 years), and temperature from 1948 – 2022 (74 years). The climate data recorded for the region over these periods is shown in Figure 2-1. Monthly mean maximum temperature ranges from 36.8°C in March to 27.4°C in July. Monthly mean rainfall ranges from 90.2 mm in February to 0.9 mm in October, with a mean annual rainfall of 317.7 mm (BoM 2022).

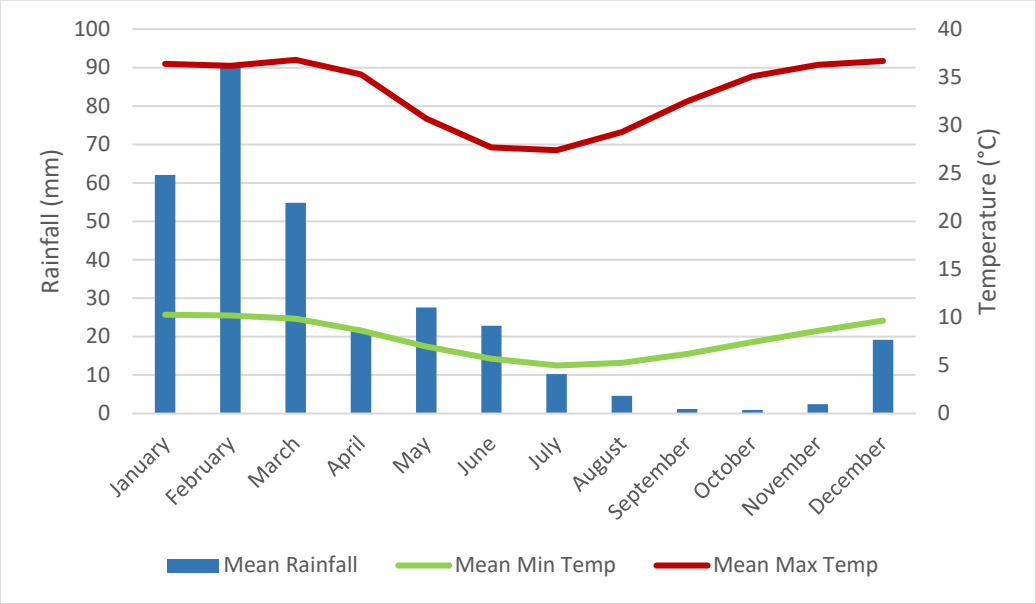


Figure 2-1. Temperature and rainfall averages for Port Hedland Airport weather station (Station No. 004032) (BoM 2022)

2.4 GEOLOGY

The Pilbara 2014 Geological Information Series dataset (Geological Survey of Western Australia 2014) features a 1:100 000 scale surface geology compilation. The digital layers are based on published maps from the 1994-2005 Pilbara Craton Mapping Project, carried out by the Geological Survey of Western Australia and Geoscience Australia under the North Pilbara National Geoscience Mapping Accord. The Study Areas are within the Wodgina (2655) map area.

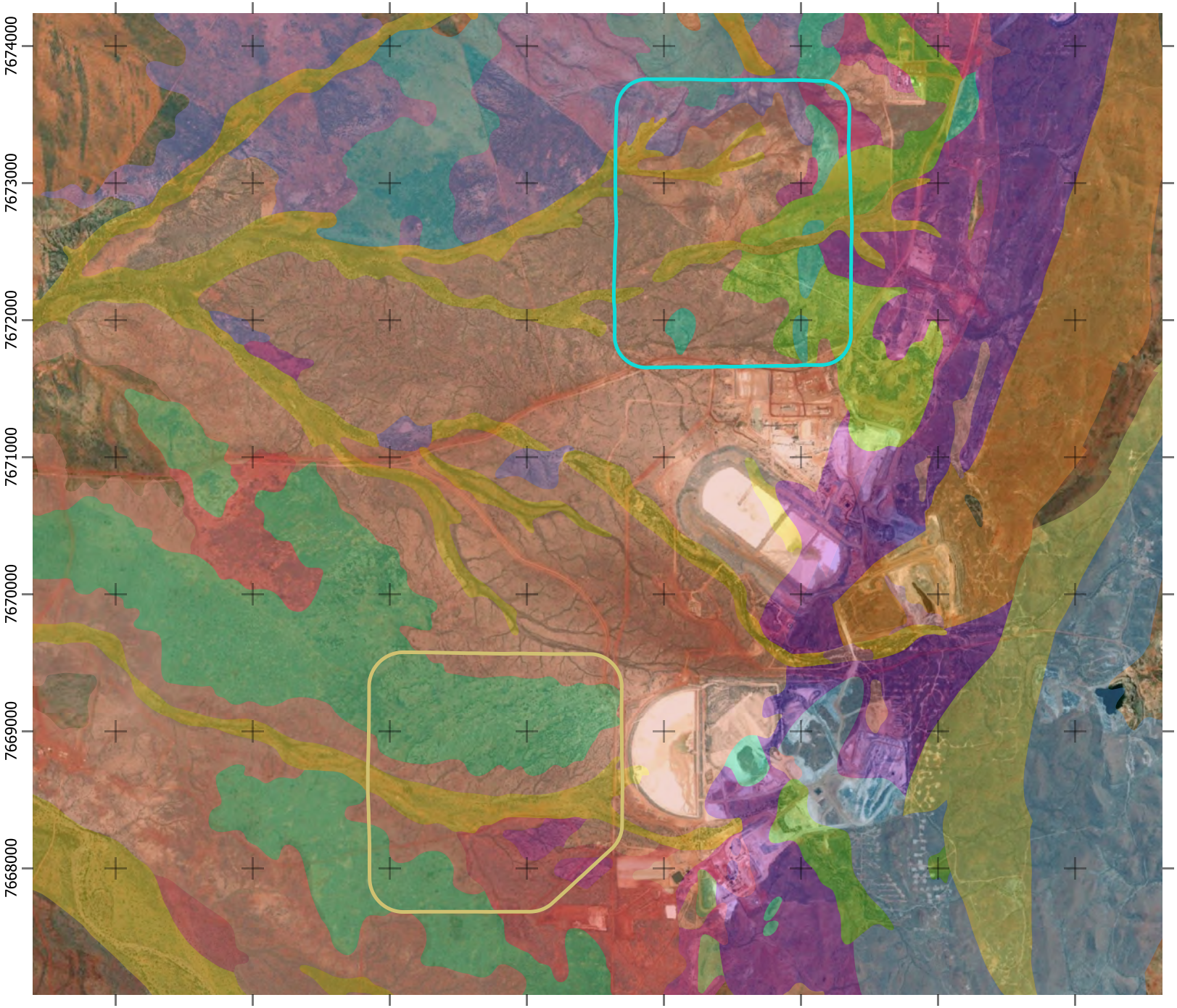
Option 2 contains the following eight geological formations:

- A-KEe-mu; Euro Basalt; Metamorphosed ultramafic rock;
- A-CLmo-xmgm-mgg; Motherin Monzogranite; Interleaved metamonzogranite, metagranodiorite, gneiss, and pegmatite; moderately to strongly foliated; intruded by abundant sheets of massive to weakly foliated muscovite-bearing metamonzogranite and pegmatite;
- A-CLmo-jmgm-mwa; Motherin Monzogranite; Interleaved seriate to porphyritic metamonzogranite, hornblende--biotite metagranodiorite, and pegmatite; strongly foliated and banded, locally gneissic; contains greenstone enclaves and pendants;
- _S1; Sandplain unit; Sandplain deposits; sand of mixed residual, sheetwash, and eolian origin; unconsolidated;
- _R1-g-pg; Residual or relict unit; Residual quartzofeldspathic sand, with quartz and rock fragments; overlying and derived from mass-wasting of granitic rocks; unconsolidated;
- _C1; Colluvial unit; Colluvial sand, silt, and gravel in outwash fans; scree and talus; proximal mass-wasting deposits; unconsolidated;
- _A2-d-k; Alluvial unit; Partly consolidated alluvial gravel, sand, and silt; local carbonate cement; dissected by present-day drainage; and
- _A1c; Alluvial unit; Sand, silt, and gravel in active drainage channels; includes clay, silt, and sand in poorly defined drainage courses on floodplains; unconsolidated.

Option 5 contains the following five geological formations:

- _C1; Colluvial unit; Colluvial sand, silt, and gravel in outwash fans; scree and talus; proximal mass-wasting deposits; unconsolidated;
- _A2-d-k; Alluvial unit; Partly consolidated alluvial gravel, sand, and silt; local carbonate cement; dissected by present-day drainage;
- _A1i; Alluvial unit; Mixed floodplain deposits; sand, silt, and clay adjacent to main drainage channels; numerous small claypans; unconsolidated;
- _A1f-cb-vb; Alluvial unit; Clay, silt, sand, and basaltic or doleritic gravel on floodplains; gilgai surface in areas of expansive clay; derived from ferromagnesian parent rock; unconsolidated; and
- _A1c; Alluvial unit; Sand, silt, and gravel in active drainage channels; includes clay, silt, and sand in poorly defined drainage courses on floodplains; unconsolidated.

The geology of the Study Areas is shown in Figure 2-2.



Legend

- TSF Option 2
- TSF Option 5
- _A1c
- _A1f-cb-vb
- _A1i
- _A2-d-k
- _C1
- _C2
- _R1-g-pg
- _S1
- A-CLmo-jmgm-mwa
- A-CLmo-xmgm-mgg
- A-DA-mats
- A-KEe-bk
- A-KEe-mba
- A-KEe-mbaq
- A-KEe-mu
- A-mty-P
- A-SR-gp

Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 31/10/2022

Geology of the Study Area

Prepared for:
Pilbara Minerals

Figure: 2-2

The soils of the Study Areas were mapped by Tille (2006). The Study Areas are situated in the Fortescue Province, in the western edge of the Nullagine Hills Zone, with influences from the Abydos Plains and Hills Zone.

The Nullagine Hills Zone is characterised by:

"Hills and ranges (with some stony plains) on volcanic and sedimentary rocks of the Pilbara Craton (including the Hamersley Basin). Stony soils with red shallow loams and sands. Spinifex grasslands with kanji and snappy gum. Located in the north-eastern Pilbara around Marble Bar and Nullagine (Tille 2006)."

The Abydos Plains and Hills Zone is characterised by:

"Stony plains (with some hills) on granitic rocks of the Pilbara Craton (East Pilbara Terrane). Red deep sandy duplexes and red shallow loams with stony soils, red sandy earths and red loamy earths. Spinifex grasslands with kanji (and some tussock grasslands). Located in the northern Pilbara between Yandeyarra Community, Bamboo Springs Station and Marble Bar (Tille 2006)."

2.5 BIOGEOGRAPHIC REGIONALISATION

The Interim Biogeographic Regionalisation for Australia (IBRA, version 7) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (Thackway and Cresswell 1995). The mapping completed by Beard (1975) provides the basis for the IBRA bioregions. IBRA mapping (Version 7), places the Project within the Pilbara Bioregion.

The Pilbara Bioregion is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges. Vegetation is predominantly mulga low woodlands or snappy gum over bunch and hummock grasses.

The Pilbara Bioregion is further subdivided into the Chichester (PIL1), Fortescue (PIL2), Hamersley (PIL3) and Roebourne (PIL4) Sub-regions. The Project lies entirely within the Chichester Sub-region.

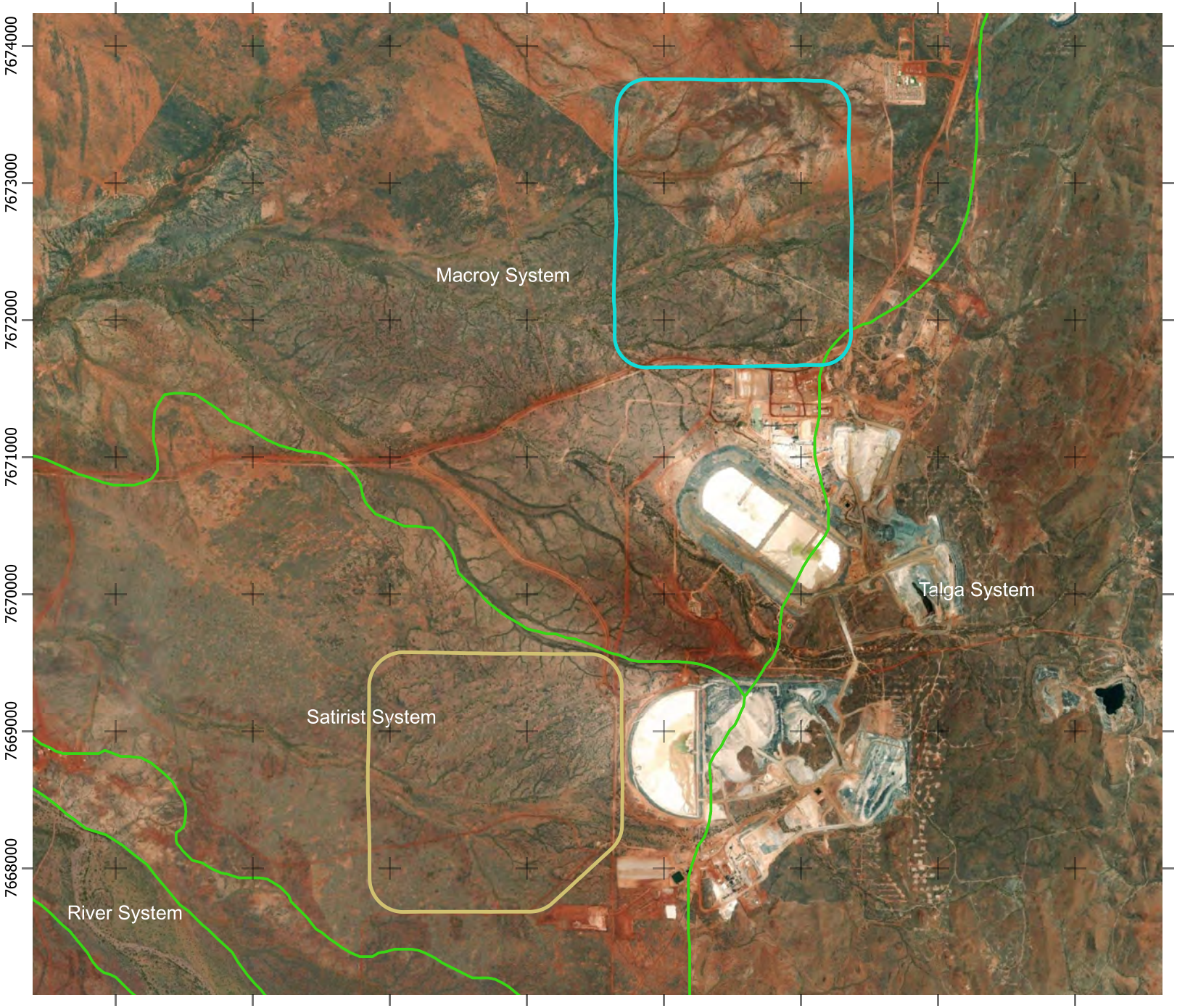
The Chichester Sub-region comprises the northern section of the Pilbara Craton and is comprised of undulating Archaean granite and basalt plains and includes significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges (Kendrick and McKenzie, 2001).

2.6 LAND SYSTEMS

Land Systems of the Pilbara region are described by van Vreeswyk *et al.* (2004). Mapping of Land Systems is available from Department of Primary Industry and Regional Development (**DPIRD**, 2019a). The Study Areas falls within three soil landscape systems, as listed in Table 2-1 and illustrated in Figure 2-3.

Table 2-1. Land Systems of the Study Areas

Land System	Geology	Description
Macroy	Level to gently undulating stony and gritty surfaced plains with occasional granite tor fields and domes and closely to moderately spaced dendritic tributary drainage floors, relief up to 25 metres (**m**)	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands
Talga	Hill and ridge tracts of mafic and ultramafic rocks (greenstones), other metamorphics and chert, relief up to 100 m	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands
Satirist	Quaternary alluvium and colluvium; clay, gravel and pebble deposits, minor Lower Proterozoic or Archaean chert, quartzite, shale and agglomerate	Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands.



Legend

- TSF Option 2
- TSF Option 5
- Soil Landscape Mapping BestAvailableDPIRD_027



Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 31/10/2022

Land Systems of the Study Area

Prepared for: Pilbara Minerals

Figure: 2-3

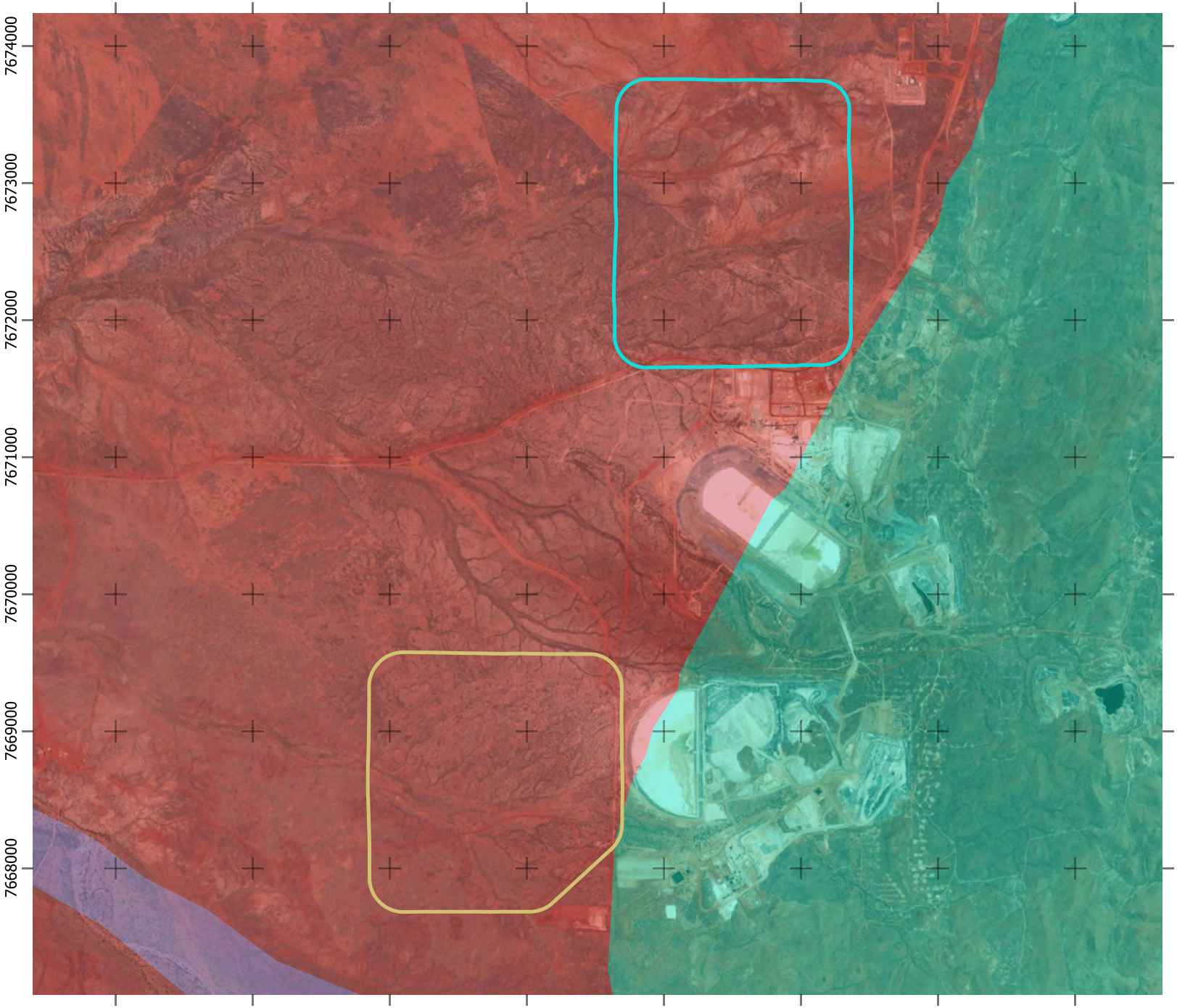
2.7 REGIONAL VEGETATION

The Study Areas are located within the Eremaean Botanical Province and contains one pre-European Beard vegetation association of the George Ranges System, and one vegetation association of the Abydos Plain – Chichester System as shown in Figure 2-4. The remaining extent of these vegetation associations is outlined in the most recent DBCA Statewide Vegetation Statistics table dated 2018 and summarised in Table 2-2 below.

Vegetation Associations within the Study Areas have over 99% pre-European Vegetation extent remaining. Conservation significance ranking of vegetation associations occurring within the Study Areas are of 'Least Concern'.

Table 2-2 Pre-European Beard Vegetation Associations within the Study Areas

Unit	Vegetation Description	Pre-European Extent (ha)	Current Extent (ha)	Pre-European Extent Remaining (%)	Current Extent within DBCA Managed Lands (%)
82	Hummock grassland with scattered bloodwoods and snappy gum *Triodia* spp., *Corymbia dichromophloia, Eucalyptus leucophloia*	2,565,901	2,553,206	99.51	11.57
93	Hummock grassland with scattered shrubs or mallee *Triodia* spp. *Acacia* spp., *Grevillea* spp. *Eucalyptus* spp	3,044,310	3,040,641	99.88	1.96



Legend

- TSF Option 2
- TSF Option 5
- 82: Hummock grassland with scattered bloodwoods and snappy gum Triodia spp. Corymbia dichromophloia Eucalyptus leucophloia
- 93: Hummock grassland with scattered shrubs or mallee Triodia spp. Acacia spp. Grevillea spp. Eucalyptus spp
- 619: Riverine; rivergum E. camaldulensis

Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 31/10/2022

Pre-European Vegetation of the Study Area

Prepared for:
Pilbara Minerals

Figure: 2-4

2.8 ENVIRONMENTALLY SIGNIFICANT AREAS

2.8.1 Conservation Estate

The Western Australian Conservation Estate includes land and waters vested in the Conservation and Parks Commission under the *Conservation and Land Management Act 1984*. The Conservation Estate is managed by the Parks and Wildlife Service of DBCA to protect WA's biodiversity, and includes National Parks, Nature Reserves, Conservation Reserves, and other areas managed primarily for biodiversity conservation (DEE 2016).

A search of the Collaborative Australian Protected Area Database returned no conservation estates located within 50 km of the Study Areas. The nearest gazetted terrestrial conservation estate is Mungaroona Range, 85 km to the south-west of the Study Areas.

2.8.2 Environmentally Sensitive Areas

Environmentally Sensitive Areas (**ESA**) are areas that are defined by the Department of Water and Environment Regulation (**DWER**) (2019) as:

- A declared World Heritage property as defined in s.13 of the EPBC Act;
- An area that is included on the Register of the National Estate, because of its natural heritage value under the Australian Heritage Council Act 2003;
- A defined wetland and the area within 50 m of the wetland;
- The area covered by vegetation within 50 m of T flora, to the extent to which the vegetation is continuous with the vegetation in which the T flora is located;
- The area covered by a TEC;
- A Bush Forever site;
- Areas covered by the Gnangara Mound Crown Land Policy and Western Swamp Tortoise Policy;
- Areas covered by lakes, wetlands and fringing vegetation of the Swan Coastal Plain Lakes Policy, including Southwest Agricultural Zone Wetlands Policy and Swan and Canning Rivers Policy; and
- Protected wetlands as defined in the Environmental Protection (Southwest Agricultural Zone Wetlands) Policy 1998.

The Australian Wetlands Database includes nationally significant wetlands (as listed in the directory of important wetlands), wetlands listed under the Ramsar convention, wetlands that are representative, rare or unique, or wetlands that are considered of international importance (DEE 2019). The nearest wetlands listed in the Directory of Important Wetlands within 150 km of the Study Areas are the Leslie (Port Hedland) Saltfields System, 80 km to the north, the De Grey River System, 85 km to the north-east, and the Fortescue Marshes, 130 km to the south-west.

Environmentally Sensitive Areas can be viewed on the DWER clearing permit system map viewer. There are no ESA's within the Study Areas.

3 METHODOLOGY

3.1 DESKTOP STUDY

The desktop study provides background information on the known attributes of flora, vegetation and fauna of the Study Areas.

3.1.1 Database Searches

A search for EPBC Act MNES was undertaken using the DCCEEW Protected Matters Search Tool (**PMST**). The PMST identifies EPBC listed flora and fauna species and communities based on predicted distributions of the species and/or their habitat, in conjunction with species records. The PMST may predict the occurrence of a species or community in an area where there are no documented records, or documented records are historic. Therefore, for this search, a search area of 30 km from a central coordinate of 697208, 7669697 (GDA 1994, MGA Zone 50) was applied to ensure relevancy for the habitats present within and adjacent to the Study Areas.

The conservation codes are described in Appendix A. The results of the PMST search are included in Appendix B.

The DBCA maintains databases for records of T and P species and communities. A request was made for a search of DBCA databases for T and P flora and fauna and the presence of TECs or Priority Ecological Communities (**PECs**). A 30 km buffer was applied to the fauna, flora, TEC and PEC search from a central coordinate of 697193, 7669699 (GDA 1994, MGA Zone 50).

Introduced flora and fauna records from within 30 km were obtained from the NatureMap database.

Table 3-1 lists the database searches conducted for the desktop study.

Table 3-1. Database Searches

Attribute	Search Area	Database	Location
Threatened and Priority Ecological Communities	30 km radius	DBCA	Figure 4-2; Section 4.1.2
	30 km radius	PMST	Appendix B
Threatened Flora	30 km radius	DBCA	Figure 4-1; Section 4.1.1
	30 km radius	PMST	Appendix B
Introduced Flora	30 km radius	NatureMap	Section 4.1.3
Threatened Fauna	30 km radius	DBCA	Figure 5-1; Section 5.1.1
	30 km radius	PMST	Appendix B
Introduced Fauna	30 km radius	NatureMap	Section 5.1.2

The DBCA fire history database (DBCA 2022) was consulted to identify local fire history.

3.1.2 Literature Review

Flora, vegetation and terrestrial vertebrate fauna surveys have been conducted in the local area for the Pilgangoora Project. The following local surveys were reviewed, and the results incorporated into the Desktop Study:

- Baseline Vertebrate Fauna Survey, Pilgangoora. Prepared on behalf of Pilbara Minerals Limited by 360 Environmental. Publication date: May 2016.
- Pilgangoora Access Road Borrow Pits - Flora and Vegetation Assessment. Prepared on behalf of Pilbara Minerals Limited by MMWC Environmental Pty Ltd. Publication date: July 2016.
- Pilgangoora Project Area – Flora, Vegetation and Fauna Assessment. Prepared on behalf of Pilbara Minerals Limited by MMWC Environmental Pty Ltd. Publication date: July 2016
- Pilgangoora Project – Stage 2 Expansion Desktop Environmental Assessment. Prepared on behalf of Pilbara Minerals Limited by Ecologia Environmental. Publication date: 26 October 2018.
- Pilbara Leaf-nosed Bat Survey, Pilgangoora Prepared for Pilbara Minerals Limited by 360 Environmental November 2015
- Pilbara Leaf-nosed Bat Roost Survey, Pilgangoora Prepared for Pilbara Minerals Limited by 360 Environmental February 2016
- Northern Quoll Survey on mining tenement M45/1266. Prepared for Pilbara Minerals Limited by Terrestrial Ecosystems, January 2020.
- Lynas Find Biological Survey - Prepared for Pilbara Minerals Limited by APM, October 2022.

3.1.3 Likelihood of Occurrence

Threatened and Priority flora, fauna and communities returned from the database searches and literature review were assessed for their likelihood of occurrence within the Study Areas using the likelihood of occurrence criteria listed in Table 3-2.

Table 3-2. Likelihood of occurrence criteria

Likelihood of occurrence	Criteria
Recorded	Identified from database records or field survey as occurring within the Study Area
Likely	Suitable habitat is present in the Study Area and the species has previously been recorded within 15 km
Possible	Suitable habitat is present within the Study Area and the species has previously been recorded between 15 – 30 km of the Study Area
Unlikely	No suitable habitat is present in the Study Area

3.2 FIELD SURVEY

3.2.1 Survey Personnel and Timing

The terrestrial vertebrate fauna survey was carried out by Dr Mitchell Ladyman. The flora and vegetation field survey was undertaken by Dr Neil Pettit assisted by Mr Danah Blache.

Acoustic analysis and bat call identification was conducted by Dr Kyle Armstrong and Yuki Konishi at Specialised Zoological, a scientific consultancy business that specialises in bats, bioacoustics and genetic identification. Dr Armstrong has 20 years' experience in environmental consultancy specialising in bats.

Table 3-3 lists the personnel involved in the field survey.

Table 3-3. Field Survey Personnel

Survey Date	Personnel	Experience	Description
4th – 8th October 2022	Dr Mitchell Ladyman	20+ years	Terrestrial vertebrate fauna survey
	Dr Neil Pettit	25+ years	Flora and vegetation survey
	Danah Blache	under instruction	

Autonomous recording devices installed during the field survey were collected at a later date.

3.2.2 Survey Conditions

The summer rainfall prior to survey was approximately average (BoM 2022). The rainfall in the Winter/Spring preceding survey was approximately double the average for the period. The higher-than-average winter rainfall is a result of a high total monthly rainfall in May of 123.8 mm, which is almost 4.5 times higher than the long-term average of 52.3 mm for the same period.

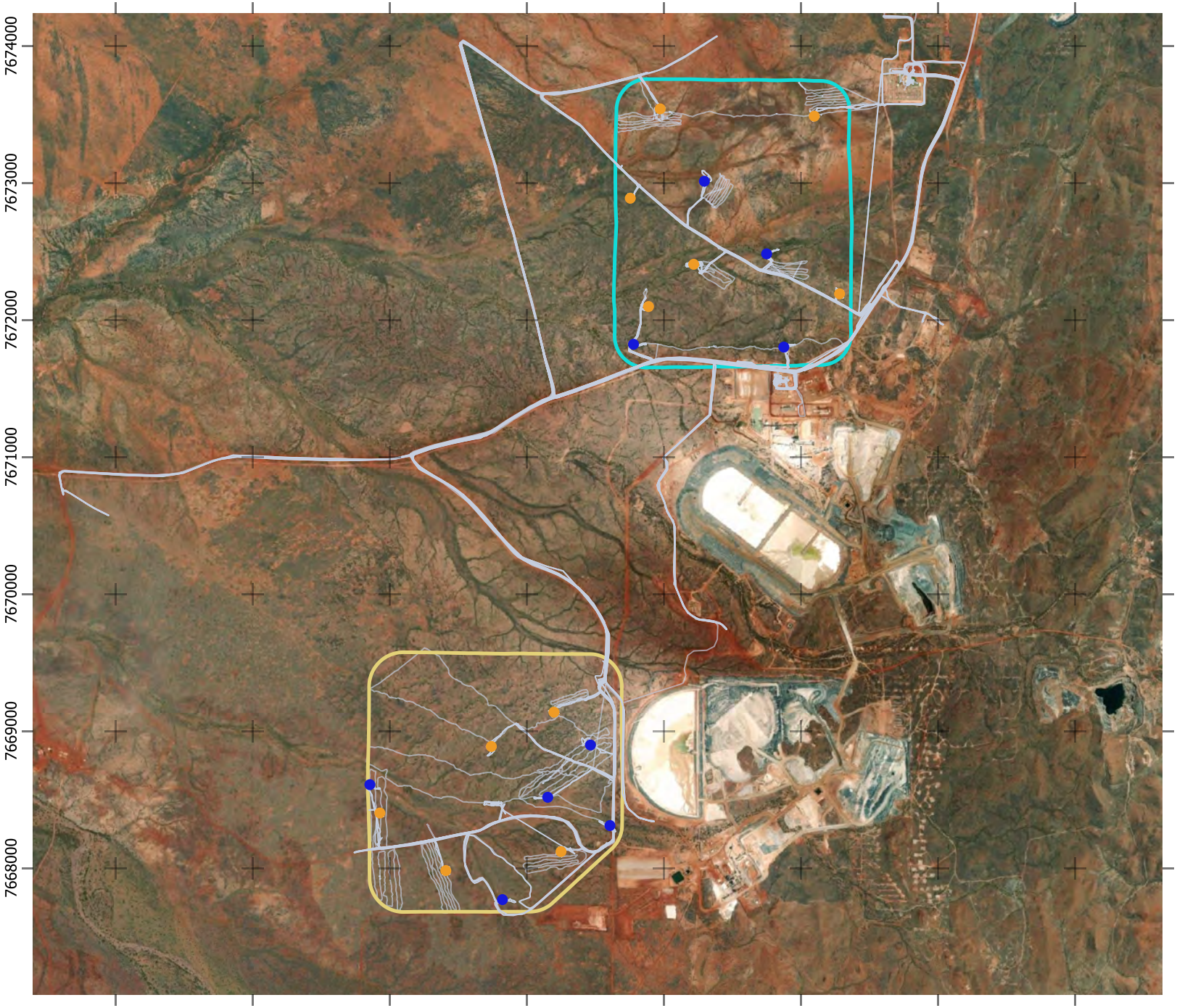
During the survey period, daytime temperatures reached a maximum of between 29.6 and 35.7 °C and a minimum of between 18.3 and 19.9°C overnight, which is typical of the time of year (BoM 2022). No rainfall was recorded during the survey period and no adverse weather conditions occurred that would impact the results of the survey.

The Study Areas are within the Eremaean botanical province. Recommended timing for flora and vegetation survey is 6-8 weeks post wet season (March – June) for Primary survey, and a Dry season survey (after winter rainfall if available) for Supplementary survey (EPA 2016). The timing of the field survey was outside of the recommended Supplementary survey period for the region, however seasonal conditions were good following a wetter than average winter. It is likely that some annual flora were absent at the time of survey.

Survey timing was within that recommended for mammals and reptiles (EPA 2020).

3.2.3 Flora and Vegetation

A detailed survey was conducted for flora and vegetation. Vegetation was sampled using 12 quadrats of 50 x 50 m and seven relevés of approximately the same size (Figure 3-1). Quadrats are vegetation survey plots which are accurately measured out as 50 x 50 m (or an area equivalent to 2500 m^2) and marked at the north-west corner using a handheld Global Positioning System (**GPS**) unit. Relevés are 'unmarked quadrats', where a centre point is marked and an area equivalent to that of a quadrat is visually approximated around this point for the purpose of estimating species composition and cover.



Legend

- TSF Option 2
- TSF Option 5
- Quadrat
- Releve
- Tracklogs

Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 01/11/2022

Flora Survey Sites

Prepared for:
Pilbara Minerals

Figure: 3-1

Field data at each survey site was recorded on a pro-forma data sheet and included the parameters listed in Table 3-4. The attributes of Detailed survey sites are provided in Appendix C.

Table 3-4. Parameters recorded at each Detailed site

Variable	Parameters
Collection attributes	Personnel/recorder; date, quadrat dimensions and marking method, photographs of the quadrat, site code.
Physical features	Landform, slope, aspect, soil attributes, ground surface cover, litter, rock type and physical attributes.
Location	Coordinates recorded in GDA94 datum using a hand-held GPS (Garmin) to accuracy approximately ± 5 m.
Vegetation	Dominant growth form, height, cover and species for the three traditional strata (upper, mid and ground) compatible with NVIS Level V (ESCAVI 2003).
Vegetation condition	Vegetation condition was assessed using the condition rating scale devised by Trudgen (1988).
Disturbance	Level and nature of disturbances (*e.g.* weed presence, fire and time since last fire, impacts from grazing, vegetation clearing, erosion).
Flora	List of all species within the quadrat including weeds and listing species average height, cover and abundance.

A flora inventory was compiled from taxa listed in Detailed survey sites and from opportunistic floristic collections throughout the Study Areas, with at least one collection made for every taxon encountered. Specimens were identified by an experienced botanical taxonomist in the Western Australia Herbarium (**WAH**) using published reference material. The nomenclature applied is consistent with Florabase (WAH 1998-).

The conservation status of all recorded flora was determined from the DBCA Wildlife Conservation Rare Flora Notice 2022, T and P Flora List 6 October 2022, and the EPBC Act List of T Flora (DCCEEW 2022). The Western Australian Organisms List database was consulted to determine if any are BAM Act Declared Plants (DPIRD 2021), and the Weeds of National Significance list to determine any WONS (DAWE 2020).

The vegetation associations were described based on their structure and species composition, as defined by quadrat and releve data, and field observations. Vegetation was mapped in the field using handheld GPS units and aerial photographs, then digitised as map figures using GIS software. Vegetation is described at the association level (Executive Steering Committee for Australian Vegetation Information (ESCAVI 2003) and referred to as Vegetation Types (EPA 2016).

Vegetation Condition was assigned using the scale developed for the Eremaean and Northern Botanical Provinces adapted from Trudgen (1988) as recommended in EPA (2016). Table 3-5 lists the six potential categories.

Table 3-5. Vegetation Condition Scale

Vegetation Condition	Eremaean and Northern Botanical Provinces adapted from Trudgen (1988)
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; *i.e.* areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs

Conservation significant flora was Targeted searched using traverses on foot and logged using a handheld GPS.

For consistency with the existing Pilgangoora operations, data analysis was applied using the method presented by MMWC Environmental (2016). A species by site matrix was prepared that included the data from the current field survey and that presented by MMWC Environmental (2016). The Primer 7 (Clarke and Gorley, 2015), software was used to perform floristic composition vegetation classification. Data was square root transformed and a resemblance matrix was constructed using the Bray Curtis similarity measure. A cluster analysis was performed using group averages. The SIMPROF routine was used to test the hypothesis that the species and/or abundances are different at each group of sites using 999 permutations and a significance level of 5%.

The completeness of the survey was tested using a species accumulation curve and applying the Michaelis-Menton model to estimate the species richness of the Study Areas.

3.2.4 Fauna

Fauna habitat assessments were performed at 25 locations. Descriptive data was recorded including soil type, landform, presence of microhabitats, disturbances and images were recorded. Site photos are included in Appendix D.

Targeted search was conducted for signs of conservation significant fauna using traverses on foot, with tracklogs recorded on a handheld GPS. Signs include scats, prints, slough skin, scratchings made during foraging and other diggings, burrows and mounds. Traverses were conducted during daylight hours. Additional traverses outside of the TSF Option areas were made by vehicle to inspect the surrounding habitats.

Eight motion-triggered cameras were deployed throughout the Study Areas between the 4th and 21st of October 2022. Table 3-6 lists the camera locations and operational days by target habitat.

Table 3-6. Motion-triggered camera setup and duration

Area	Targeted Fauna Habitat	Location (GDA 1994 MGA zone 50)	Camera	Trap nights
Option 2	Creek	695873, 7672225	MSC04	16
Option 5	Plains	695424, 7669233	MSC06	17
Option 5	Plains	695413, 7668137	MSC07	16
Option 2	Plains	697421, 7672046	MSC10	16
Option 2	Plains	697068, 7673526	MSC11	14
Option 5	Creek	695612, 7668308	MSC12	16
Option 5	Creek	694835, 7668460	MSC14	17
Option 2	Creek	695652, 7673136	MSC16	16
Total				**128**

Four Anabat Swift acoustic bat recording devices were deployed for between 11 and 17 nights between the 4th and 21st of October 2022 for a total of 59 trap nights. Table 3-7 lists the acoustic bat recording devices deployed, the habitat type targeted, and the number of trap nights.

Bat call analysis was performed by Dr Kyle Armstrong of Specialised Zoological. A technical report with specifications on the analysis method is included as Appendix E. The scope of the analysis was limited to the detection of the conservation significant Ghost bat *Macroderma gigas* and Pilbara leaf-nosed bat *Rhinonicteris aurantia*. Attention was also given to determining if the Northern leaf-nosed bat *Hipposideros stenotis,* is present. This species is generally not known to occur in the Pilbara but database records from 2012 indicate it may be present in the local area.

Table 3-7. Acoustic bat recording device location and duration

Area	Habitat	Location (GDA 1994 MGA zone 50)	Acoustic Bat Recorder	Trap nights
Option 2	Creek	695871, 7672225	622904	16
Option 5	Creek	695611, 7668308	642029	11
Option 5	Creek	694819, 7668471	660630	17
Option 2	Creek	696909, 7671805	660654	15
Total				**59**

Four Phillips DVT-7110 Digital Voice-Tracer Sound Recording devices were deployed for recording bird calls in .wav format, with the Night parrot as the target. Devices were deployed for three nights from the 4th to the 7th of October 2022, for a total of twelve trap nights. Locations were selected that provided the highest potential habitat quality. Habitat quality for Night parrot was assessed with reference to habitats described and depicted by the Night Parrot Recovery Team (2022).

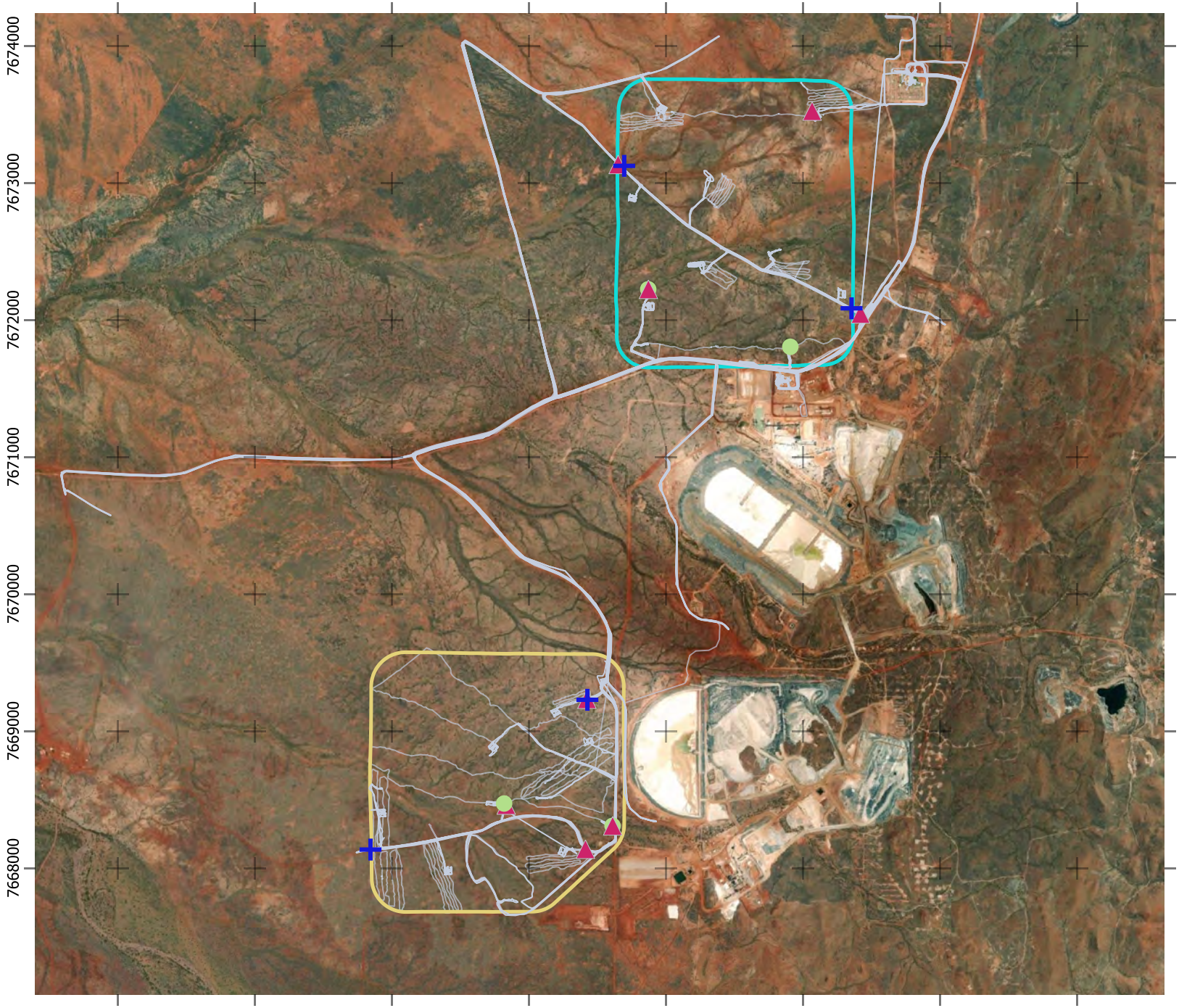
Table 3-8 lists the recording devices deployed in each habitat type, and the number of trap nights.

Table 3-8. Acoustic bird recording devices

Area	Habitat	Location (GDA 1994 MGA zone 50)	Acoustic Bird Recorder	Trap nights
Option 5	Plains	695427, 7669228	NP001	3
Option 2	Plains	697356, 7672086	NP002	3
Option 5	Plains	693844, 7668135	NP003	3
Option 2	Creek	695696, 7673126	NP004	3
Total				**12**

Acoustic recordings were assessed with reference to the calls available on the Night Parrot Recovery Team (2022) website. Sound files recorded between 17:00 and 06:30 and were assessed for Night parrot calls from 18:30 – 20:30 (2 hours post-sunset) and from 03:00 – 05:00 (2 hours pre sunrise). In addition to listening to call playbacks, a spectrograph of bird calls were viewed using the Audacity® software package. A profile of Night parrot calls was created by playing the calls available on the Night Parrot Recovery Team (2022) website, for comparison with recorded bird calls. The assessments were also made with reference to descriptions of known vocalisations of the Night parrot as published by Leseberg *et al.* (2019).

Nomenclature within this report is applied according to the WA Checklist of Terrestrial Vertebrates (Western Australian Museum, 2022). Figure 3-2 shows the location of motion-triggered cameras, bat acoustic recording devices and targeted searches. Detailed fauna habitat assessments were made at the locations where cameras and acoustic recording devise were deployed, and during traverses.



Legend

- TSF Option 2
- TSF Option 5
- Acoustic recorder - Bats
- Acoustic recorder - targeting Night Parrot
- Motion triggered camera
- Targeted Search Tracklogs

Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 01/11/2022

Fauna Survey Sites

Prepared for:
Pilbara Minerals

Figure: 3-2

3.3 CONSTRAINTS

Several limitations may arise during field survey EPA (2016 and 2020). These potential survey limitations are listed below in Table 3-9 with comments on the constraint to the outcomes of the survey.

Table 3-9. Survey Constraints

Factor	Impact of survey outcomes
Access Problems	Not a constraint All of the Study Areas were accessed.
Experience levels	Not a constraint The personnel were suitably qualified
Scope: Flora and Vegetation	Not a constraint Survey was carried out at a level of Detailed assessment
Scope: Fauna	Not a constraint The survey was carried out at a level of Targeted and basic assessment, suitable for the size and intensity of the proposed Project and the availability of previous local survey.
Timing, weather, season, cycle	Not a constraint The Study Areas are within the Eremaean Botanical district. Rainfall in the season prior to survey was higher than average and therefore, weather and seasonal conditions were not a constraint. No inclement weather occurred during the survey period that would impact the detection of target fauna. Survey timing was within that recommended for mammals and reptiles. Conditions were unsuitable for water birds and amphibians, however the assessment of habitat availability for these groups was possible.
Sources of information	Not a constraint Previous biological reports and database records are available for the locality and region.
Completeness: Flora and vegetation	Not a constraint The scope was completed. Four plant specimens (3% of the collection) were not able to be determined to the species level due to sterile specimens. Modelling indicates the survey captured 84% of the floristic richness in the area.
Completeness: Fauna	Not a constraint The scope was completed. The survey resulted in no ambiguous identifications of bat calls, bird calls or photos.

4 FLORA AND VEGETATION RESULTS

4.1 DESKTOP STUDY

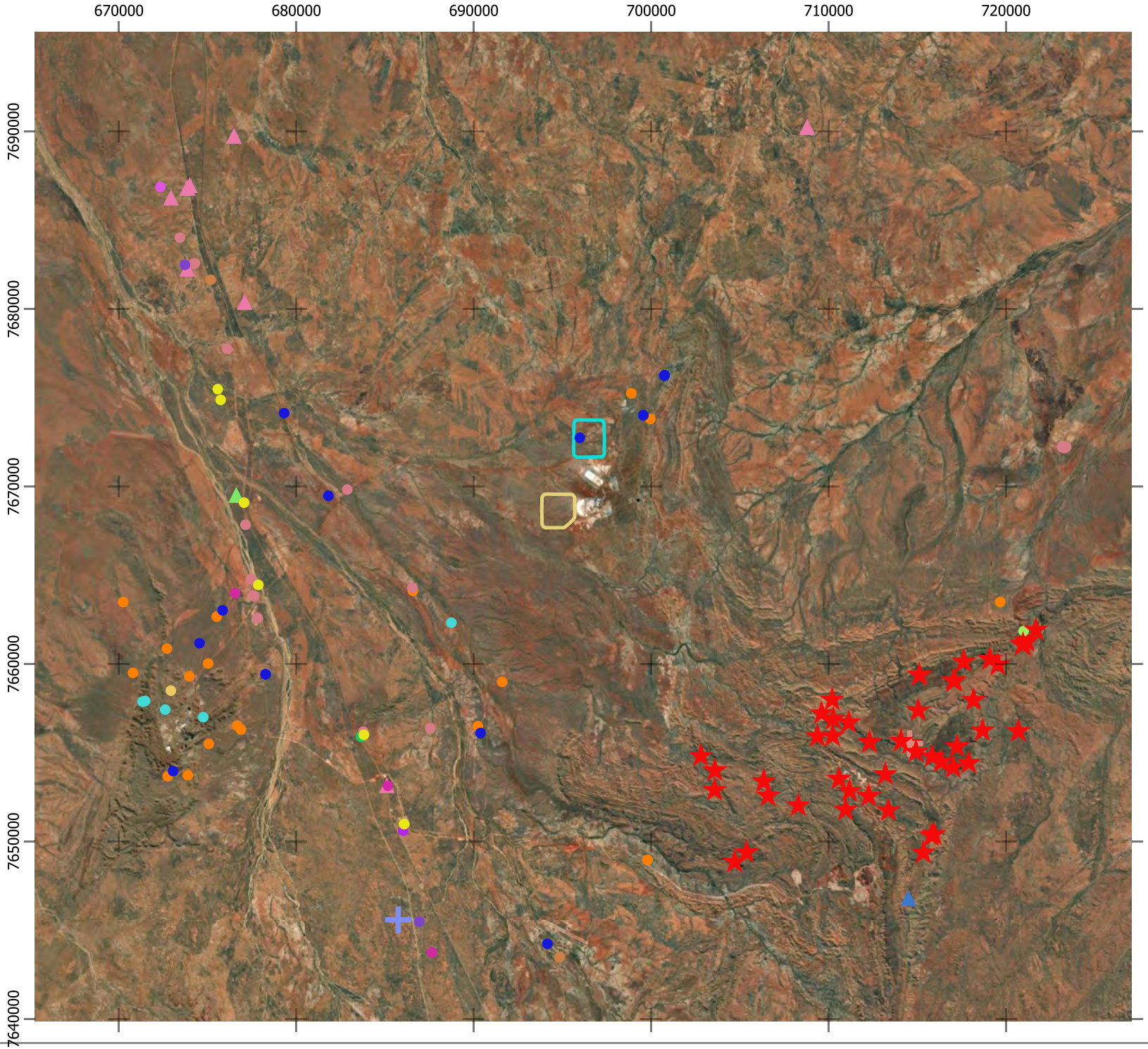
4.1.1 Significant Flora

No T Flora listed under the BC Act or EPBC Act have been previously recorded within the Study Areas. One P Flora species has been previously recorded in the Option 2, *Triodia chichesterensis* which is listed as P3 in WA.

One T flora species has been recorded within 30 km, *Quoya zonalis* (formerly *Pityrodia* sp. Marble Bar, listed as Endangered under the EPBC Act and BC Act). Two P1, thirteen P3, and three P4 species have records within 30 km of the Study Areas.

No additional T species were returned from the PMST or literature review, however a local record of *Rothia indica* subsp. *australis* (APM 2022) increased the likelihood of occurrence from Possible to Likely.

T and P flora returned from the DBCA database with records within 30 km of the Study Areas are shown in Figure 4-1.



Legend

TSF Option 2
TSF Option 5

Threatened
- Quoya zonalis

Priority 1
- Acacia leeuweniana
- Themeda sp. Panorama (J. Nelson et al. NS 102)

Priority 3
- Eragrostis crateriformis
- Euphorbia clementii
- Euploca mutica
- Gomphrena leptophylla
- Gymnanthera cunninghamii
- Nicotiana umbratica
- Phyllanthus hebecarpus
- Rothia indica subsp. australis
- Stylidium weeliwolli
- Terminalia supranitifolia
- Triodia basitricha
- Triodia chichesterensis
- Vigna triodiophila

Priority 4
- Bulbostylis burbidgeae
- Goodenia nuda
- Ptilotus mollis

Scale: @ A4
1: 300,000

0 5 10 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 01/11/2022

Threatened and Priority Flora Database Records

Prepared for:
Pilbara Minerals

Figure: 4-1

An assessment of the likelihood of occurrence of these 19 species within the Study Areas was performed using the criteria listed in Table 3-2. The results of the assessment are listed in Table 4-1.

Table 4-1. Threatened and Priority Flora Likelihood of Occurrence

Species	Cons. Code		Preferred Habitat	Likelihood of Occurrence
	BC Act	EPBC Act		
Acacia leeuweniana	P1		Gritty, skeletal red-grey sandy loam, light orange-brown gravelly sand, on granite. In rock fissures in outcrops, among boulders.	Unlikely to occur.
Bulbostylis burbidgeae	P4		Granitic soils. Granite outcrops and cliff bases.	Unlikely to occur.
Eragrostis crateriformis	P3		Clayey loam or clay. Creek banks, depressions.	Possible. Suitable habitat in clay depressions.
Euphorbia clementii	P3		Gravelly hillsides, stony grounds.	Likely. Suitable habitat in stony rises.
Euploca mutica	P3		Hummock grassland and sandplains.	Likely. Suitable habitat in sandy rises.
Gomphrena leptophylla	P3		Open flats, sandy creek beds, edges salt pans and marshes, stony hillsides.	Possible. All habitats suitable.
Goodenia nuda	P4		Has been previously found in drainage lines of red-brown loamy sand or sandy loam and in disturbed roadside areas	Possible. Suitable habitat in creeks and roadsides.
Gymnanthera cunninghamii	P3		Sandy soils.	Possible. Suitable habitat in sandy creeks.
Nicotania umbratica	P3		Typically grows in shelter of large boulders on rocky outcrops and in shallow soils	Unlikely to occur.
Phyllanthus hebecarpus	P3		Granite boulders/outcropping	Unlikely to occur.
Ptilotus mollis	P4		Stony hills and screes.	Unlikely to occur.
Quoya zonalis	EN	EN	Steep, rocky, sandstone conglomerate and granite slopes in skeletal, brown, sandy loam soils of the Capricorn Land System	Unlikely to occur.

Rothia indica subsp. *australis*	P3	Sandy soils. Seasonally inundated areas, sandhills and flats.	Likely. Suitable habitat in depressions and sandy rises.
Stylidium weeliwolli	P3	Gritty sand soil, sandy clay. Edge of watercourses.	Possible. Sandy creek edges.
Terminalia supranitifolia	P3	Sand. Among basalt rocks.	Unlikely to occur.
Themeda sp. Panorama (J. Nelson *et al.* NS 102)	P1	Has been found growing along watercourses and creeklines and on rocky substrate	Unlikely to occur.
Triodia basitricha	P3	Occurs on rocky and gravelly slopes of mountains or low hills.	Unlikely to occur.
Triodia chichesterensis	P3	Occurs on sand or loam over rocky or gravelly substrates, often with quartzite.	Recorded.
Vigna triodiophila	P3	Local record among dolerite boulders on very steep upper slope. Stony red-brown clay loam.	Unlikely to occur.

4.1.2 Significant Vegetation

There are no TECs listed under the BC Act or EPBC Act known to occur within the Study Areas. One Priority 3 Ecological Community is located approximately 30 km west of the Study Areas; the Gregory Land System (Figure 4-2).



Legend

- TSF Option 2
- TSF Option 5
- Gregory Land System



Scale: @ A4
1: 300,000

0 5 10 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 01/11/2022

Threatened and Priority Ecological Communities Database Records

Prepared for:

Pilbara Minerals

Figure: 4-2

4.1.3 Introduced Flora Species

NatureMap returned eight introduced flora, including three species that are classed as Declared pests in WA, and two WONS. Eight introduced flora species have been recorded locally by MMWC Environmental (2016), including one Declared pest.

Table 4-2 lists the introduced flora species recorded within 30 km of the Study Areas. Where a local record and a database record is available, the local record is adopted as the source.

Table 4-2. Introduced Flora Records within 30 km of the Study Areas

Species	Common Name	BAM Act Listing	WONS	Source
Aerva javanica	Kapok Bush	Permitted – S11	No	MMWC
Arivela viscosa (formerly *Cleome viscosa)*	Tickweed	Permitted – S11	No	Database
Boerhavia coccinea	Tar Vine	Permitted – S11	No	Database
Calotropis procera	Rubber Bush	Declared Pest – S22(2) (Exempt)	No	Database
Cenchrus ciliaris	Buffel Grass	Permitted – S11	No	MMWC
Cenchrus setiger	Birdwood Grass	Permitted – S11	No	MMWC
Chloris barbata	Purpletop Chloris	Permitted – S11	No	MMWC
Cynodon dactylon	Couch Grass	Permitted – S11	No	MMWC
Flaveria trinervia	Speedy Weed	Permitted – S11	No	MMWC
Opuntia elata	Prickly Pear	Declared Pest – S11(2) (C3 Restricted)	Yes	Database
Opuntia stricta	Common Prickly Pear	Declared Pest – S11(2) (C3 Restricted)	Yes	MMWC
Passiflora foetida var. *hispida*	Stinking Passion Flower	Permitted – S11	No	MMWC
Tamarix aphylla	Athel Pine	Declared Pest – S22(2) (Exempt)	Yes	MMWC

4.2 FIELD SURVEY

4.2.1 Flora

A total of 123 species of flora were recorded within the Study Areas, comprising 117 native species and six introduced species. Four specimens in the collection (3% of the collection) could not be identified beyond genus level due to the lack of flowering parts or fruiting bodies.

The Fabaceae (pea family, 29 native) Poaceae (grass family, 19 native, two introduced), Malvaceae (13 native species) and Amaranthaceae (eight native species, one introduced) were the most species-rich families recorded. Twenty-eight families were recorded across the Study Areas.

The complete list of plant species recorded within the Study Areas is presented in Appendix F. The mean species richness was 23 species per quadrat, slightly less than the MMWC Environmental (2016) survey which included 49 detailed sites with an average species richness of 25.

A species accumulation curve was performed with a modelled Michaelis-Menton species richness of 146, indicating that the floristic survey was approximately 84% complete.

The survey recorded 29 species not previously recorded for the Pilgangoora Project area. These species are identified in Appendix F and bring the total richness for the Pilgangoora Project area to 260 including subspecies, and varieties.

Floristic groups identified in the cluster analysis were organised into vegetation types and are discussed in the following section.

The introduced flora species recorded are detailed in Section 4.2.6.

4.2.2 Vegetation Types

The DBCA fire history database did not identify any fire activity within the Study Areas. Field survey identified that some areas within the Study Areas were recently burned and were regenerating. Fire history was estimated based upon the level of regeneration given the good growth conditions following significant rainfall in the 2022 calendar year.

Three vegetation types are described for the Study Areas, as summarised in Table 4-3 and detailed in the subsections below. As the TSF options areas are considered as an extension to the existing Pilbara Minerals Pilgangoora Project, the vegetation coding system previously used at the site has been retained and extended. MMWC Environmental (2016) described vegetation type using the numerals 1 to 6 and the letters a to c to group sites by landform and floristics respectively. APM (2022) adopted the approach and described vegetation types using the numerals 6 to 11. Vegetation types reported here are labelled from 12 onwards and are different from those recorded previously.

Distribution of vegetation types at a scale of 1: 15,000 is shown in Figure 4-3. The dendrogram resulting from the cluster analysis is shown in Appendix C, followed by the site data sheets and photos.

Table 4-3. Vegetation Types

Code	Landform	Vegetation description	Option 2		Option 5	
			ha	%	ha	%
12a	Undulating plains	Isolated low *Corymbia hammersleyana* over mid to tall, isolated shrubs of *Acacia tumida, Acacia adsurgens* and *Acacia inaequilatera* with hummock grassland of *Triodia angusta, Triodia wiseana* and *Triodia lanigera*	277.5	78.2	293.6	89.2
13a	Creeks	Low open woodland of *Eucalyptus camaldulensis*, *Corymbia hammersleyana* and *Eucalyptus victrix*; sparse mid to tall shrubland of *Acacia tumida, Acacia stellaticeps* and *Acacia bivenosa* over	66.9	18.9	20.8	6.3

Code	Landform	Vegetation description	Option 2		Option 5	
			ha	%	ha	%
		*Triodia epactia, *Cenchrus ciliaris* and **Cenchrus setiger* tussock/hummock grassland.				
14a	Drainage depression	*Corymbia hammersleyana* low open woodland over sparse forbland/low shrubland of *Streptoglossa odora*, *Goodenia lamprosperma* and *Solanum diversiflorum*.	0	0	2.0	0.6
D		Disturbed – clear of vegetation	10.4	2.9	12.8	3.9



Legend

- TSF Option 2
- 12a: Isolated low Corymbia hammersleyana over mid to tall isolated shrubs of Acacia tumida Acacia adsurgens and Acacia inaequilatera with hummock grassland of Triodia angusta Triodia wiseana and Triodia lanigera
- 13a: Low open woodland of Eucalyptus camaldulensis Corymbia hammersleyana and Eucalyptus victrix; sparse mid to tall shrubland of Acacia tumida Acacia stellaticeps and Acacia bivenosa over Triodia epactia *Cenchrus ciliaris and *Cenchrus setiger tussock/hummock grassland.
- D: Disturbed clear of vegetation

Scale: @ A4
1: 15,000

0 200 400 m

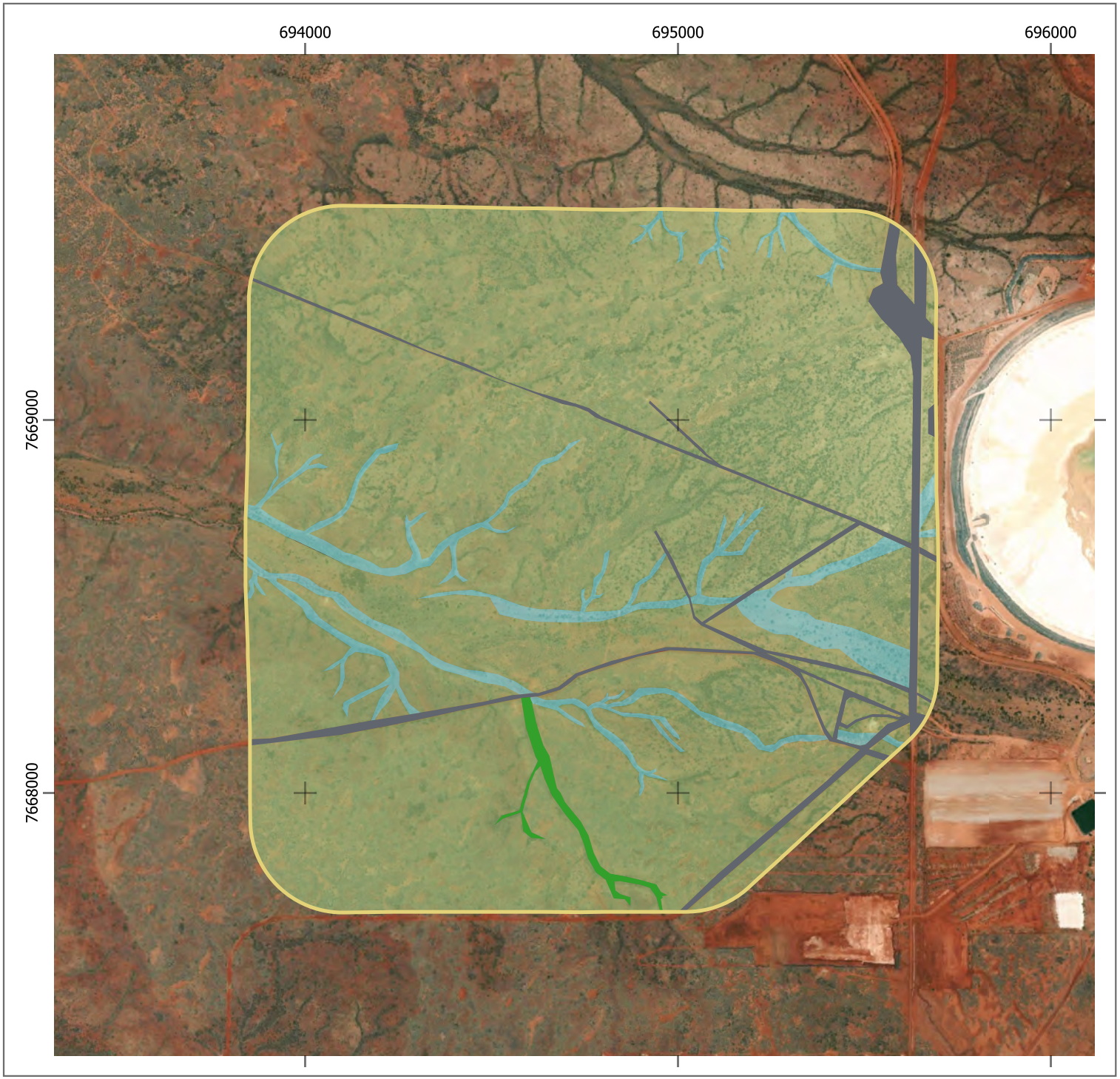
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 09/11/2022

Vegetation - TSF Option 2

Prepared for:
Pilbara Minerals

Figure: 4-3a



Legend

- TSF Option 5
- 12a: Isolated low Corymbia hammersleyana over mid to tall isolated shrubs of Acacia tumida Acacia adsurgens and Acacia inaequilatera with hummock grassland of Triodia angusta Triodia wiseana and Triodia lanigera
- 13a: Low open woodland of Eucalyptus camaldulensis Corymbia hammersleyana and Eucalyptus victrix; sparse mid to tall shrubland of Acacia tumida Acacia stellaticeps and Acacia bivenosa over Triodia epactia *Cenchrus ciliaris and *Cenchrus setiger tussock/hummock grassland.
- 14a: Corymbia hammersleyana low open woodland over sparse forbland/low shrubland of Streptoglossa odora Goodenia lamprosperma and Solanum diversiflorum.
- D: Disturbed
  clear of vegetation

Scale: @ A4
1: 15,000

0 200 400 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 09/11/2022

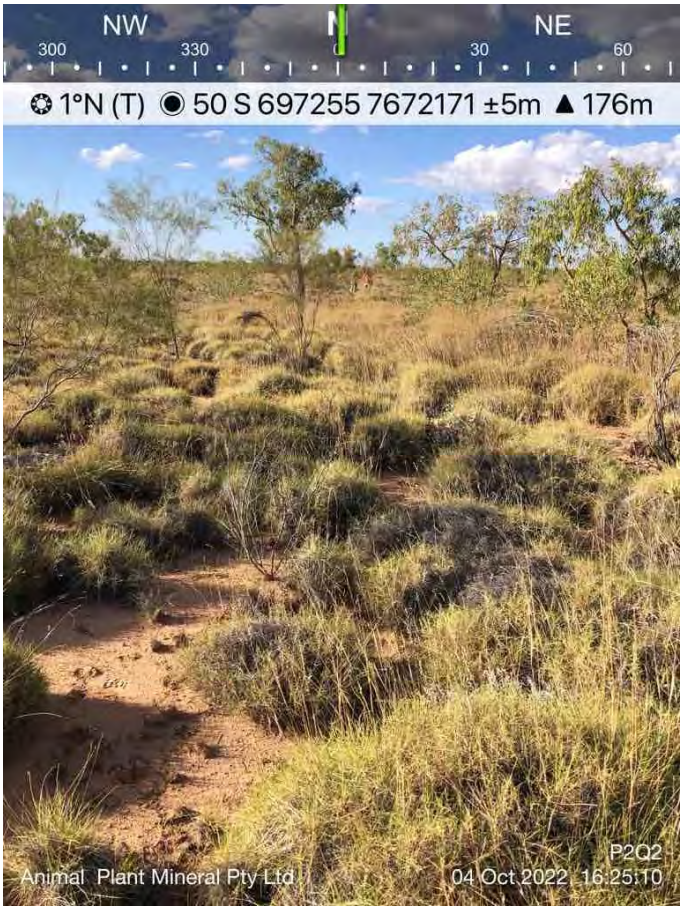
Vegetation - TSF Option 5

Prepared for:
Pilbara Minerals

Figure: 4-3b

Landform: Undulating Plains

Vegetation Type: 12a



Isolated low *Corymbia hammersleyana* over mid to tall, isolated shrubs of *Acacia tumida, Acacia adsurgens* and *Acacia inaequilatera* with hummock grassland of *Triodia angusta, Triodia wiseana* and *Triodia lanigera.*

The ground layer is the dominant vegetation stratum and is characterised by a diverse hummock grassland of *Triodia angusta, Triodia wiseana, Triodia lanigera, Triodia epactia* and *Triodia brizoides*. Tussock grasses such as *Eriachne mucronata, Eragrostis eriopoda* and *Heteropogon contortus* occasionally occur in low numbers.

This community occurs on the higher ground, on undulating plains between the drainage features. The soils are variable from sandy to clayey. The higher areas are sandy and sometimes have a cover of small stones at the surface. The lower areas have a higher clay content and evidence of seasonal inundation is present. The *Acacia* mid story occurs in higher density in areas where run on occurs such as shallow drainage depressions but is generally a tall and sparse or isolated shrub layer. The occasional *Corymbia hammersleyana* overstory occurs where this vegetation type adjoins creek areas. Occasionally on the highest ground, very low (*e.g.*, one m high) rock outcrops are present.

Condition: Impacts from cattle grazing are low. No weeds were recorded. The condition of this vegetation is Very Good. Some areas are recovering from recent fire and are regenerating.

Detailed sites: P2Q1, P2Q2, P2Q3, P2Q5, P2Q6, P2R2, P5Q1, P5Q2, P5Q3, P5Q5, P5Q6, P5R4.

Total richness: 76 species. Average richness: 20.4 species

Introduced/exotic taxa: *Flaveria trinervia* occasionally present.

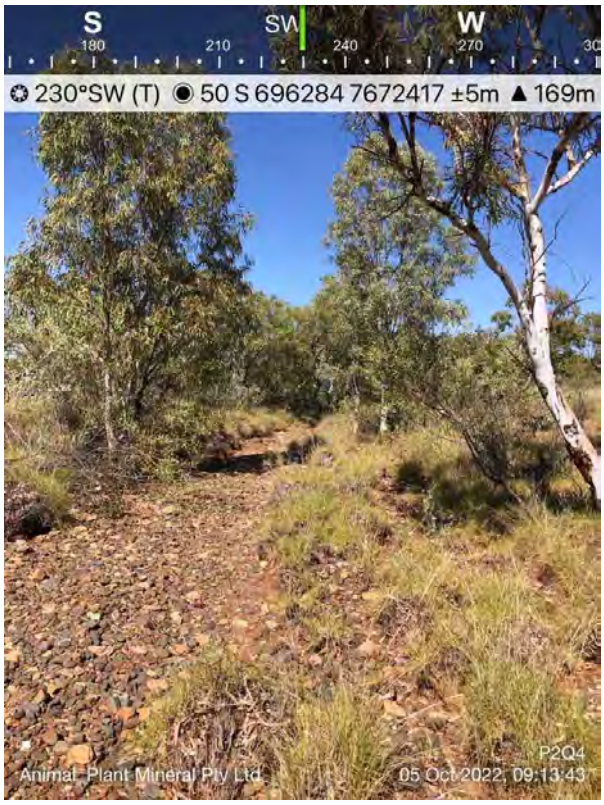
Conservation significant species: None recorded

Landform – Creek

Vegetation Type: 13a Low open woodland of *Eucalyptus camaldulensis*, *Corymbia hammersleyana* and *Eucalyptus victrix*; sparse mid to tall shrubland of *Acacia tumida, Acacia stellaticeps* and *Acacia bivenosa* over *Triodia epactia, *Cenchrus ciliaris* and **Cenchrus setiger* tussock/hummock grassland.

This community occurs in the creeklines with a rocky sandy loam soil. Riparian banks are often present with alluvial loamy soils. Creeks are all ephemeral with no permanent pools present.

Condition: Impacts from cattle grazing are moderate, and agricultural weeds **Cenchrus setiger* and **C. ciliaris* are present, and heavily grazed. The environmental week Kapok is also often present. The condition of this vegetation is Good.



Detailed sites: P2Q4, P2R1, P2R3, P2R4, P5Q4, P5R1, P5R2, P5R5.

Total richness: 83 species. Average richness: 27.5 species

Introduced/exotic taxa: The exotic agricultural grasses *Cenchrus setiger* (Birdwood grass) and *Cenchrus ciliaris* (Buffel Grass) are dominant species in the understory within this vegetation type. The environmental week *Aerva javanica* (Kapok) is common in low numbers. *Flaveria trinervia, Triumfetta pentandra* and *Malvastrum americanum* occasionally present.

Conservation significant species: None recorded

Landform – Degraded drainage depression

Vegetation Type: 14a *Corymbia hammersleyana* low open woodland over sparse forbland/low shrubland of *Streptoglossa odora*, *Goodenia lamprosperma* and *Solanum diversiflorum*.

This community occurs in a first order creek line, with red loam soils with a granite gravel cover. This community is highly degraded, with no midstory present and the groundcover degraded by high intensity grazing. Groundcover is dominated by disturbance colonists and unpalatable species, with some heavily grazed weedy **Cenchrus* grasses present. There is an overstory of low *Corymbia hamersleyana* in the southern extent, in the northern extent the overstory is lacking.

Condition: Impacts from cattle grazing are high, erosion is present and the agricultural weed **Cenchrus ciliaris* is present and heavily grazed. The condition of this vegetation is Poor.

Detailed sites: P5R3

Total richness: 17 species.

Introduced/exotic taxa: **Cenchrus ciliaris* is present. Likely also **Cenchrus setiger*, low detectability due to heavy grazing.

Conservation significant species: none recorded.



4.2.3 Vegetation Condition

Vegetation condition across the Study Areas was within the categories Good, Poor and Completely Degraded, with most of the Study Areas in Good condition (Table 4-4; Figure 4-4). The primary sources of disturbance on site are moderate to high grazing impact from cattle and roads to support the pastoralism activities, and several weed species, primarily through the creek lines and predominantly grasses valued for pastoralism. Additional tracks are present in support of the nearby mining activity.

The Study Areas have recent fire (< 2 years) in some of the plains areas, otherwise being long unburned.

Table 4-4. Vegetation condition within the Study Areas

Vegetation Condition	TSF Option 2		TSF Option 5	
	Area (ha)	Area (%)	Area (ha)	Area (%)
Very Good	277.5	78.2	293.6	89.2
Good	66.9	18.9	20.8	6.3
Poor	0	0	2.0	0.6
Completely Degraded	10.4	2.9	12.8	3.9



Legend

- TSF Option 2
- TSF Option 5
- Very Good
- Good
- Poor
- Completely Degraded

Scale: @ A4
1: 40,000

0 500 1,000 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 09/11/2022

Vegetation Condition

Prepared for:
Pilbara Minerals

Figure: 4-4

4.2.4 Significant Flora

No species listed as T under the EPBC Act or BC Act were recorded during the survey.

No Priority flora species were recorded.

A database record for *Triodia chichesterensis* is within the Option 2 area. The species has a limited distribution and has been found only in a narrow area in the central Chichester region of the Pilbara of WA. The areas immediately to the west and east of its known distribution are poorly explored, but it is likely to be restricted to an area <100 km beyond current collections, given intensive collecting efforts in the Pilbara (Anderson *et al*. 2017). Collection records indicate that florets are observed between February–April and in August.

The Study Areas are in the central part of the range of this species, which is significant from the perspective of determining it from the closely related *Triodia lanigera* (Anderson *et al*. 2017). Where the two co-occur in the south it can be difficult to determine them based on morphological and distributional parameters. Where the two co-occur in the north, there is a subtle but consistent substrate change that marks the shift in species, with *T. lanigera* occurring on sandier soils and *T. chichesterensis* on rockier soils with quartzite pieces. In the northern species range, it can usually be morphologically distinguished from *T. lanigera* by its shorter and less hairy leaves and less branched inflorescences.

The database record within the Option 2 area was recorded on rocky soils with quartzite. It is likely that *Triodia chichesterensis* is present within the Option 2 area, likely restricted to low rises with rocky soils containing quartzite.

An additional eight species were determined to be possibly occurring or likely to occur based upon the availability of suitable habitat. Of these, one is a perennial shrub and would therefore have been present at the time of survey. The remaining seven are annual herbs or small herbaceous perennials that may not have been present due to seasonal conditions.

4.2.5 Significant Vegetation

No vegetation types occurring within the Study Areas are analogous to any known TEC's or PEC's.

Two species that may be associated with groundwater dependant ecosystems were recorded in the Study Areas. These are *Eucalyptus camaldulensis* and *Eucalyptus victrix*, recorded in vegetation type 13a. The Bureau of Meteorology Groundwater Dependent Ecosystems (**GDE**) Atlas indicates this area has a low potential for terrestrial GDE from the national assessment.

4.2.6 Introduced Flora

Six introduced flora species were recorded in the Study Areas and are listed in Table 4-5. No Declared Weeds or WONS were recorded.

Table 4-5. Introduced Flora Recorded in the Study Areas

Species	Common name	Description
BAM Act S11 - Permitted		
Aerva javanica	Kapok	Erect, much-branched perennial herb, 0.4-1.6 m high. Flowers white from January to October. Often found growing on sandy soils and along drainage lines.
Cenchrus ciliaris	Buffel grass	Tufted or sometimes stoloniferous perennial, grass-like or herb. 0.2 - 1.5 m high. Flowers purple from February to October. Grows on white, red, or brown sand, stony red loam, or black cracking clay.
Cenchrus setiger	Birdwood grass	Erect, tussocky, stoloniferous perennial, herb or grass-like. Grows to 0.5 m high. Flowers cream to purple from April to May. Grows on brown sands, red loam, or pindan soils on sand dunes, plains, rangelands, stony hillsides, or floodplains.
Flaveria trinervia	Speedy weed	An erect, annual herb preferring wet areas. Often in disturbed areas.
Malvastrum americanum	Spiked malvastrum	Erect perennial, herb or shrub, 0.5-1.3 m high. Fl. yellow-orange, Apr to Jul. Orange/red/yellow sands, gritty alluvial sand, black/brown clay, alluvial cracking clays, limestone, calcrete. Stony ridges and hillsides, floodplains, along drainage lines.
Triumfetta pentandra	-	Woody annual, herb or shrub, to 1.5 m high. Fl. yellow-green, Apr to May. Brown sand, black clayey sand, red-brown clay, sandstone. Sandbank above river flood plain, forest edges, coastal sites, disturbed areas.

The agricultural weeds *Cenchrus ciliaris* and *C. setiger* were recorded in the plains on the western side of the Study Areas where cattle grazing occurs at a high intensity, and tracks are frequent. Where found, these weeds were heavily grazed.

The environmental weed *Aerva javanica* was most common on the high ridge line and infrequent in the rocky hills. The remaining weeds were recorded in low numbers predominantly in the creeks.

5 TERRESTRIAL VERTEBRATE FAUNA RESULTS

5.1 DESKTOP STUDY

5.1.1 Significant Fauna

The DBCA database returned 16 species of significant fauna that have previously been recorded within 30 km of the Study Areas. Of these, four are listed as migratory bird species (**MI**) and one as Other Specifically Protected (**OS**). Record locations of T and P fauna in relation to the Study Areas are shown in Figure 5-1.

No T or P fauna species have previously been recorded within the Study Areas.

The PMST returned 11 additional species, six T and five MI. These are species that do not have records within 30 km but where modelling has identified that suitable habitat is known to occur or may occur.

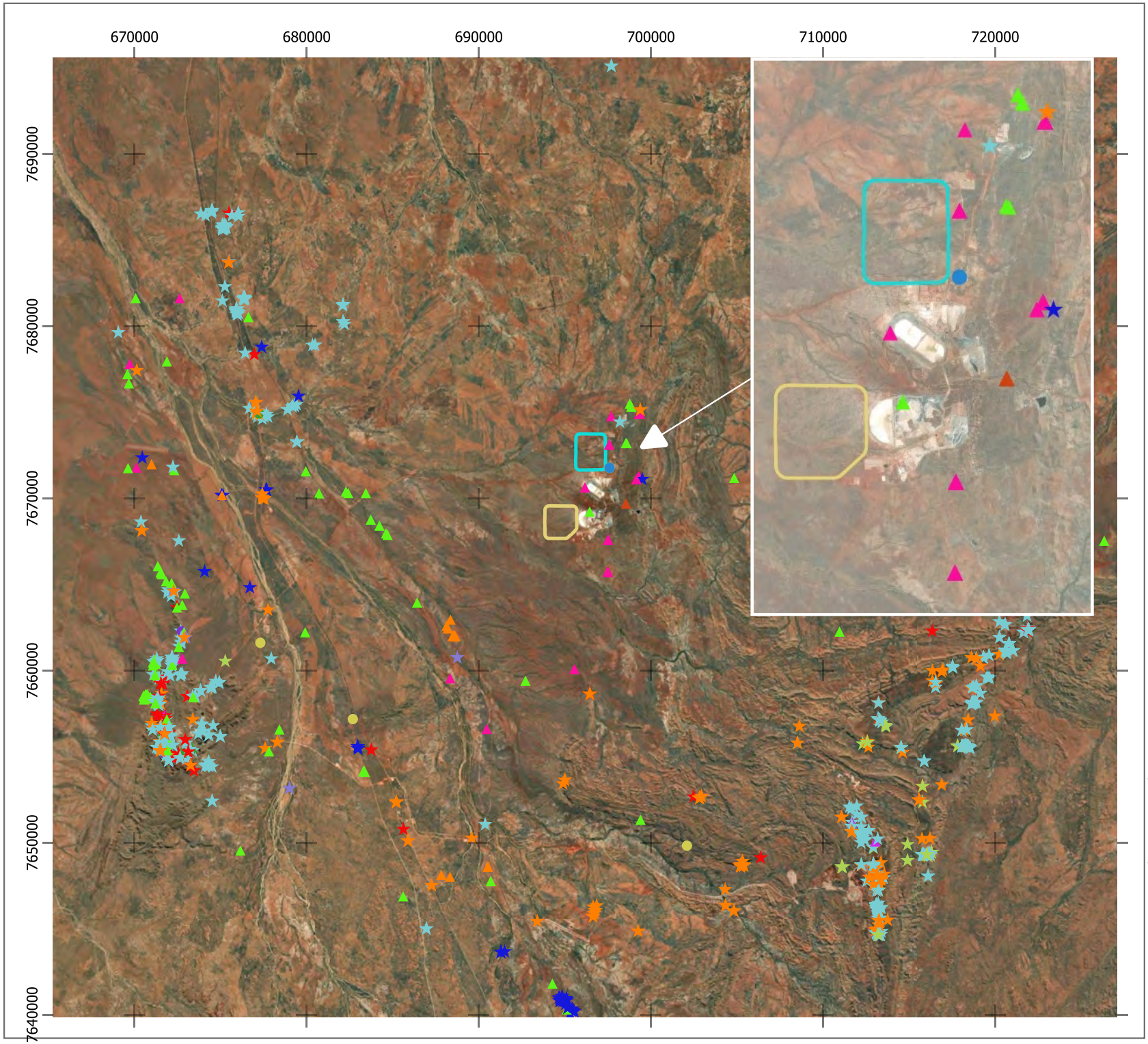
The Literature review returned additional information about the locations and abundance of Pilbara leaf-nosed bat and Northern quoll records.

Database search results of T, P and MI fauna within 30 km of the Study Areas are listed in Table 5-1, with the outcome of the likelihood of occurrence assessment. The complete assessment including the preferred habitat relative to those available in the Study Areas and records in the local area is included in Appendix G.

5.1.2 Introduced Fauna

NatureMap records for eight introduced fauna recorded within 30 km of the Study Areas were returned and are listed below:

- Camel (*Camelus dromedarius*);
- Cat (*Felis cattus*);
- Cattle (*Bos taurus*);
- Dog (*Canis lupus*);
- Donkey (*Equus asinus*)
- Fox (*Vulpes vulpes*)
- Horse (*Equus caballus*); and
- House mouse (*Mus musculus*).



Legend

TSF Option 2
TSF Option 5

Threatened

- Dasyurus hallucatus
- Falco hypoleucos
- Liasis olivaceus barroni
- Macroderma gigas
- Macrotis lagotis
- Rhinonicteris aurantia (Pilbara)

Priority

- Anilios ganei
- Dasycercus blythi
- Hipposideros stenotis
- Lagorchestes conspicillatus leichardti
- Pseudomys chapmani
- Sminthopsis longicaudata

Migratory and Other Specially Protected

- Actitis hypoleucos
- Apus pacificus
- Charadrius veredus
- Falco peregrinus

Scale: @ A4
1: 300,000

0 5 10 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 02/11/2022

Threatened and Priority Fauna Database Records

Prepared for:
Pilbara Minerals

Figure: 5-1

Table 5-1. Significant fauna database records and likelihood of occurrence

Species	Common Name	Conservation Code		Assessment of Occurrence
		BC Act	EPBC Act	
Actitis hypoleucos	Common sandpiper	MI	MI	Possible. No saline or coastal habitats available. Freshwater habitats are likely to be seasonally present in the drainage lines, however there are no permanent or semi-permanent pools. The undulating plains habitat would receive run-on following significant rainfall. Clay in the lower areas suggests inundation occurs following significant rainfall. Wading habitat would be available at these times.
Calidris acuminata	Sharp-tailed sandpiper	MI	MI	
Calidris ferruginea	Curlew sandpiper	CR	CR, MI	
Calidris melanotos	Pectoral sandpiper	-	MI	
Numenius madagascariensis	Eastern curlew	CR	CR, MI	
Apus pacificus	Fork-tailed swift	MI	MI	Possible. Utilises a broad array of habitats.
Charadrius veredus	Oriental plover	MI	MI	Likely. Suitable habitat in the seasonally inundated areas.
Erythrotriorchis radiatus	Red goshawk	VU	VU	Unlikely. Not within the known range of the species distribution.
Falco hypoleucos	Grey falcon	VU	VU	Likely. All areas are suitable for foraging. No suitable nesting habitat.
Falco peregrinus	Peregrine falcon	OS	-	Likely. All areas are suitable for foraging. No suitable nesting habitat.
Glareola maldivarum	Oriental pranticole	MI	MI	Possible. Suitable habitat in the seasonally inundated areas.
Hirundo rustica	Barn swallow	MI	MI	Possible. Suitable habitat in the seasonally inundated areas.
Motacilla cinerea	Grey wagtail	MI	MI	Unlikely. No opportunities for fast flowing water.
Motacilla flava	Yellow wagtail	MI	MI	Possible. Suitable habitat in the seasonally inundated areas.
Pezoporus occidentalis	Night parrot	CR	EN	Possible. No local records. Habitat modelling includes the Study Areas at the extremity of the species potential extent. Foraging resources are limited.

Species	Common Name	Conservation Code		Assessment of Occurrence
		BC Act	EPBC Act	
Rostratula australis	Australian painted-Snipe	EN	EN	Unlikely. No habitat occurs in the Study Areas. Vegetation too open to provide well vegetated shallows.
Dasycercus blythi	Brush-tailed mulgara	P4	-	Possible. Sandy rises in the undulating plains habitat is suitable.
Dasyurus hallucatus	Northern quoll	EN	EN	Likely. Suitable foraging habitat in the creeks but of low quality. No suitable denning habitat available.
Hipposideros stenotis	Northern leaf-nosed bat	P2	-	Unlikely. Not within the known range of the species distribution.
Lagorchestes conspicillatus leichardti	Spectacled hare-wallaby	P4	-	Unlikely. Historic records nearby however habitat is too open to be suitable.
Macroderma gigas	Ghost bat	VU	VU	Likely. Foraging habitat available. No roosting habitat available.
Macrotis lagotis	Greater bilby	VU	VU	Possible. Suitable habitat includes the undulating plains habitats.
Pseudomys chapmani	Western pebble-mound mouse	P4	-	Present. Mounds located in the undulating plains where suitable pebbles occur.
Rhinonicteris aurantia	Pilbara leaf-nosed bat	VU	VU	Likely. No roosting habitat available, foraging quality of habitats is Low.
Sminthopsis longicaudata	Long-tailed dunnart	P4	-	Unlikely. No suitable habitat.
Anilios ganei	Gane's blind snake (Pilbara)	P1	-	Unlikely. No suitable habitat.
Liasis olivaceus subsp. *baronni*	Pilbara olive python	VU	VU	Unlikely. No suitable habitat.
Liopholis kintorei	Great desert skink	VU	VU	Unlikely. No records in the local area. May occur 10 km to the east.

5.2 FIELD SURVEY

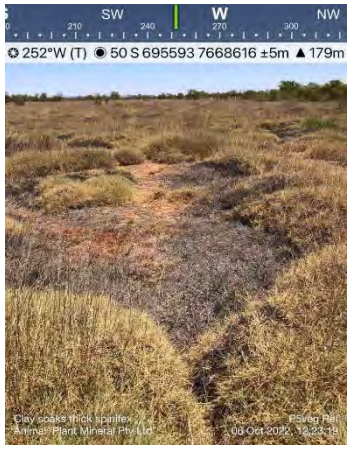
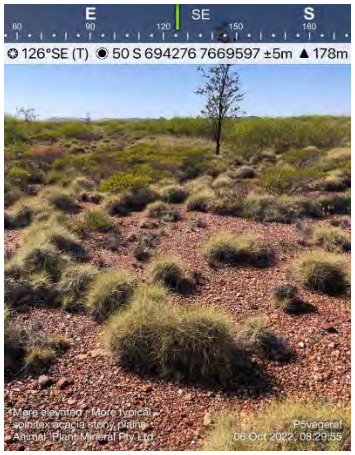
5.2.1 Fauna Habitats

The Study Areas are characterised by undulating plains dissected by ephemeral creeks. There are higher ranges to the east and water sheds from these into the Study Areas and continues through to the west. The presence of water is ephemeral and no permanent or semi-permanent water is available. The undulating plains has stony surface on the highest areas, sand surface on the lower rises and clay soils in the depressions. This arrangement is often referred to as gilgai. The lower clay areas are likely to be inundated following significant rainfalls.

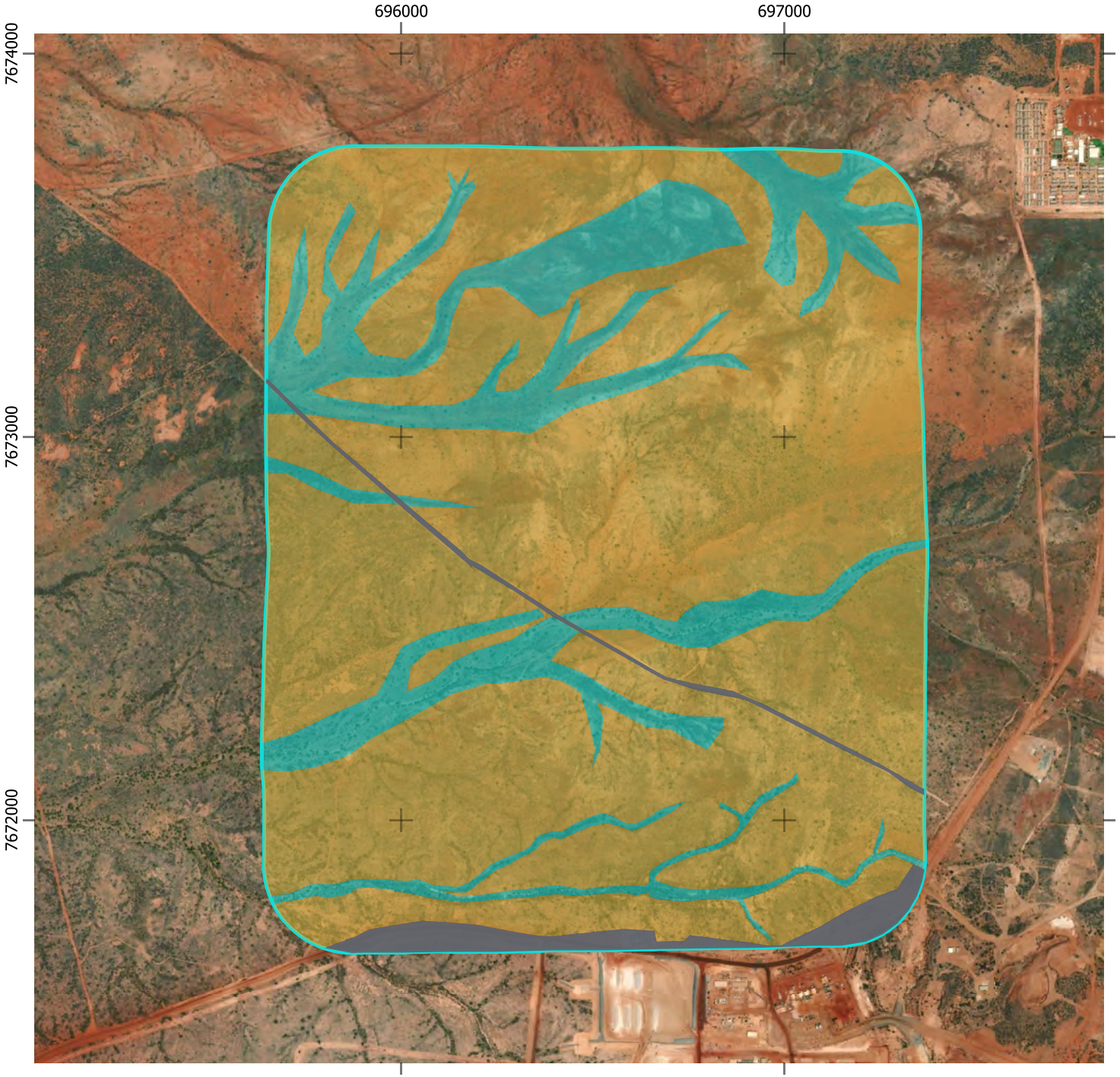
Two fauna habitats are described for the Study Areas and are summarised in Table 5-2 below. Whilst the inundated clay depressions offer a different set of microhabitats to the sandy and stony rises, the scale of the patterning is too fine to be described as separate habitats and they are grouped as undulating plains.

The distribution of fauna habitats is shown in Figure 5-2. Photos of the habitat assessment locations are shown in Appendix D.

Table 5-2. Fauna Habitats within the Study Areas

Habitat Code	Name	Sites	Description	Photo	Extent in Study Area (ha)	
					Option 2	Option 5
FH1	Undulating plains	MSC06 MSC07 MSC10 MSC11 NP001 NP002 NP003 BM01 BM02 BM03 BM04 BM05 BM06 BM07 BM08 BM09 BM10 BM11	Undulating plains with clay soils in the lowest areas interspersed with higher ground of sandy and stony surface soils. Seasonal inundation likely to occur in the lower areas. Sandy rises suitable for burrowing species. Stony areas suitable for pebble mound mouse. Hummock grasses in some areas are large. The vegetation consists of Isolated low *Corymbia hammersleyana* over mid to tall, isolated shrubs of *Acacia tumida, Acacia adsurgens* and *Acacia inaequilatera* with hummock grassland of *Triodia angusta, Triodia wiseana* and *Triodia lanigera*	 	277.5 (78.2%)	293.6 (89.2%)

Habitat Code	Name	Sites	Description	Photo	Extent in Study Area (ha)	
					Option 2	Option 5
FH2	Ephemeral creeks	MSC04 MSC12 MSC14 MSC16 AS622904 AS642029 AS660630 AS660654 NP004 RV001	Ephemeral creeklines with rocky sandy loam soil. Riparian banks are often present with alluvial loamy soils. Creeks are all ephemeral with no permanent or semi-permanent pools present. Sandy soils is suitable for burrowing species. Occasional trees but generally of insufficient size to have hollows and no fallen hollow branches observed. This habitat may act as a wildlife corridor for birds, bats, mammals, and reptiles. The condition of the habitat is poor, the cover of weedy grasses is high, there is a low leaf litter or accumulation of dead wood to provided microhabitats, and a high grazing pressure. The vegetation consists of Low open woodland of *Eucalyptus camaldulensis*, *Corymbia hammersleyana* and *Eucalyptus victrix*, sparse mid to tall shrubland of *Acacia tumida, Acacia stellaticeps* and *Acacia bivenosa* over *Triodia epactia, *Cenchrus ciliaris* and **Cenchrus setiger* tussock/hummock grassland.		66.9 (18.9%)	22.8 (6.9%)
D	Disturbed				10.4 (2.9%)	12.8 (3.9%)



Legend

- TSF Option 2
- FH1 Undulating Plains
- FH2 Ephemeral Creeks
- D Disturbed

Scale: @ A4
1: 15,000

0 200 400 m

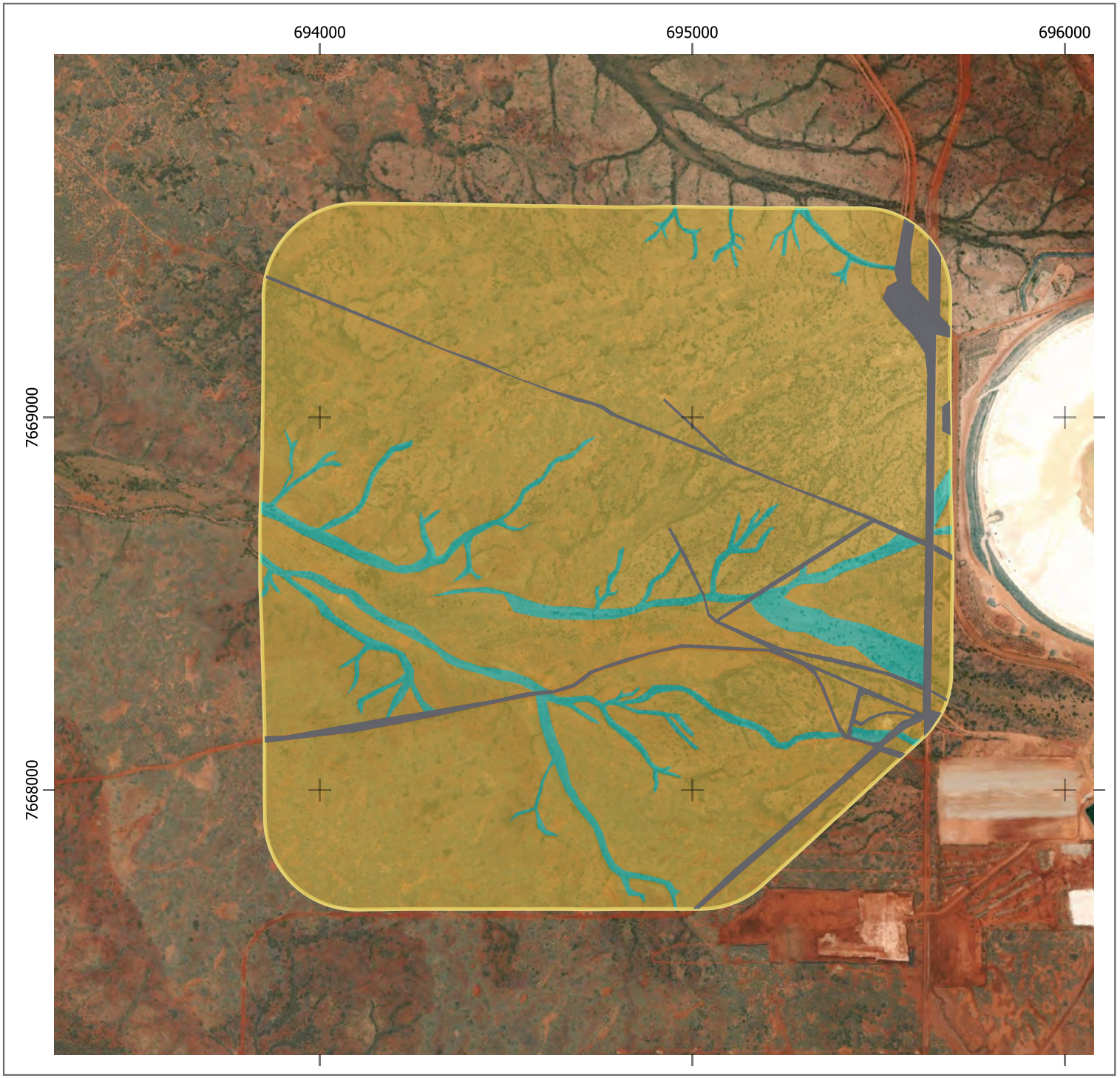
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH | Approved: ML | Date: 24/11/2022

Fauna Habitat - TSF Option 2

Prepared for:
Pilbara Minerals

Figure: 5-2a



Legend

- TSF Option 2
- FH1 Undulating Plains
- FH2 Ephemeral Creeks
- D Disturbed

Scale: @ A4
1: 15,000

0 200 400 m

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 24/11/2022

Fauna Habitat - TSF Option 5

Prepared for:
Pilbara Minerals

Figure: 5-2b

5.2.2 Acoustic bat recorders

The recording dataset comprised a total of 59 recording nights from four bat detector units.

Acoustic processing of the bat detector recordings was conducted separately for each of Ghost bat Pilbara leaf-nosed bat and Northern leaf-nosed bat using methods optimised for the detection of their unique echolocation call types.

No call sequences of the target species were detected.

5.2.3 Motion triggered cameras

Motion-triggered cameras returned 17 captures of individuals, where records from the same species were separated by more than one hour.

One capture of a conservation significant species was made at MSC014 of a Pebble mound mouse.

Non-target captures returned a diversity of species, including Introduced fauna. Table 5-3 lists the incidental records from the motion-triggered cameras.

Table 5-3. Non-target captures

Common name	Species name	Number of captures
Birds		
Torresian crow	*Corvus orru*	1
Spinifex pigeon	*Geophaps plumifera*	2
Magpie lark	*Grallina cyanoleuca*	3
Mammals		
Cow	*Bos taurus*	3
House mouse	*Mus musculus*	3
Pebble mound mouse	*Pseudomys chapmanii*	1
Reptiles		
Ring-tailed dragon	*Ctenophorus caudicinctus*	1
Striped skink	*Ctenotus* sp.	1
Monitor	*Varanus gouldii*	1

All captures were of good image quality and were able to be identified.

Three captures were of cattle, which is expected as the land is within a station and pastoralism is the active land use within all the surveyed areas. The introduced House mouse was captured on three occasions.

5.2.4 Acoustic bird recording devices

No Night parrot calls were recorded in the 48 hours of assessed recordings.

5.2.5 Traverses

During traverses, the following fauna signs were identified:

- One digging sign that cannot be discluded as bilby signs;
- One abandoned and collapsed burrow system that may once have hosted Brush-tailed mulgara; and
- 13 Western pebble mouse mounds (five active, four intermediate and four inactive).

No signs of Northern quoll, Night parrot or Spectacled hare-wallaby were observed.

No T or MI bird species were observed, however seasonal conditions were unsuitable.

Notes were taken on habitat quality, disturbances, and the availability/unavailability of habitat micro-niches.

5.2.6 Conservation Significant Fauna

5.2.6.1 Northern Quoll

In the Pilbara region, the species tends to prefer the Rocklea, Macroy and Robe land systems (Biota Environmental Services 2008). These land systems are comprised of basalt hills, mesas (and buttes of limonites), high and low plateaux, lower slopes, occasional tor fields and stony plains supporting either hard or soft spinifex grasslands (van Vreeswyk *et al.* 2004).

The Northern quoll has also been recorded in other land systems which are comprised of sandstone and dolomite hills and ridges, shrublands, sandy plains, clay plans and tussock grasslands and coastal fringes including dunes, islands and beaches (Biota Environmental Services 2008).

Northern quoll has been recorded on several occasions within the Pilgangoora Project area (DBCA Database record, Ecologia Environmental 2018; Terrestrial Ecosystems 2020, APM 2022). Locally this species seems to be most encountered in the boulder hill tops habitat of the north/south tending ridgeline running along the eastern half of the Pilgangoora Project area. This is the most rugged landform in the local area, at the highest elevations. Boulders on the ridge tops form a mosaic of cracks and crevices large enough to provide denning habitat for the quoll. Two camera records and three quoll scats were recorded in this habitat by APM (2022). Ecologia Environmental (2018) recorded five scats and Terrestrial Ecosystems (2020) made captures on 12 cameras within this habitat type.

Within 30 km of the Study Areas, species records are predominantly occurring within rocky outcrop habitats. There are also occasional records in the Turner River and larger tributaries of the Turner River, 16 km to the west of the Study Areas.

There is no possible denning habitat for the Northern quoll in the Study Areas as rocky boulder outcrop habitats are not present and trees are of insufficient size to have developed hollows and very sparse litter is present. Foraging or dispersal habitat is recognised to be any land comprising predominantly native vegetation in the immediate area (*i.e.* within 1 km) of shelter habitat, quoll records or land comprising predominately native vegetation that is connected to shelter habitat within the range of the species (CoA 2016).

Habitat critical to the survival of the Northern quoll and populations important for the long-term survival of the Northern quoll are defined in CoA (2016) and are present in the Pilgangoora Project area.

Habitat critical to the survival of the Northern quoll relevant to the Pilgangoora Project area includes:

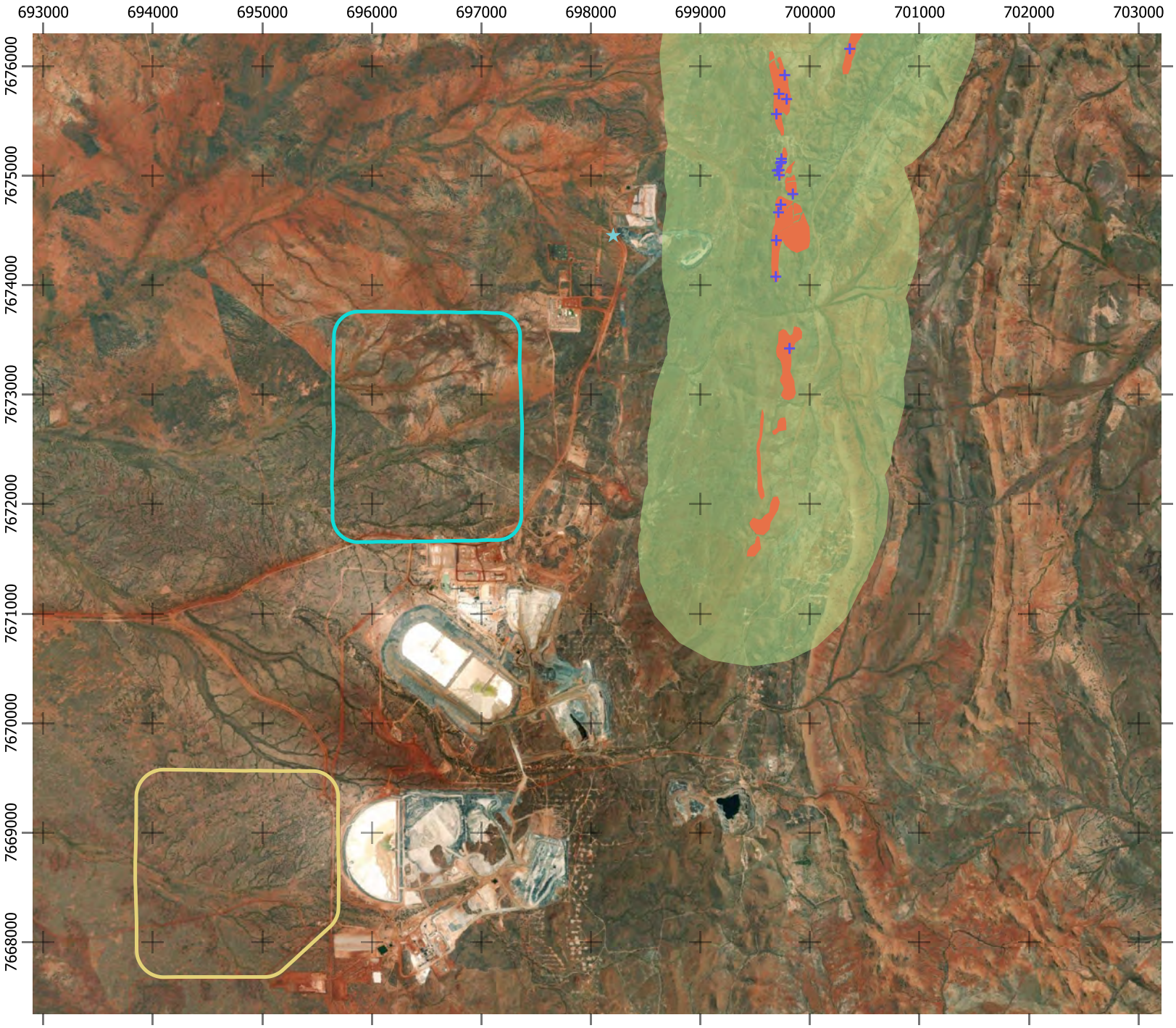
- Rocky outcrop habitat in the range 4 km to the east of the Study Areas;
- areas of native vegetation within 1 km of Rocky outcrop habitat; and
- dispersal and foraging habitat associated with or connecting the population within the Rocky outcrop habitat to other nearby populations or foraging habitats.

No quoll records or signs were recorded in creeks. Whilst in other environs creek lines would be a dispersal and foraging habitat for Northern quoll, in the Study Areas this habitat type does not appear to be frequented by the species.

All habitats occurring within the Study Areas may be utilised by the species, at some time, to forage and or during dispersal activities; however, their significance to the species will vary depending on resource availability and connectivity.

An opportunistic sighting of Northern quoll was made in 2018 1.5 km to the northwest of the Option 2 Study Area near to the entrance of an active mining area, demonstrating the species moves reasonable distances from the core shelter habitat, including into disturbed areas. Foraging habitat within the Study Areas is likely to vary depending on resource availability, which may be seasonally dependant.

Figure 5-3 shows the location of Northern quoll records, Rocky outcrop habitat, areas within 1 km of the Rocky outcrop habitat and the database record. These areas are defined by CoA (2016) as habitat critical to the survival of Northern quoll. The Study Areas do not intersect with these habitats. It is possible the Northern quoll occasionally uses the Study Areas for foraging and dispersal, but the areas do not provide critical habitat.



Legend

- TSF Option 2
- TSF Option 5
- Northern quoll database record (2018)
- Northern quoll records Pilgangoora project studies
- Rocky Outcrop habitat
- 1 km buffer applied to Rocky outcrop habitat

Scale: @ A4
1: 50,000

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 02/11/2022

Northern Quoll

Prepared for:
Pilbara Minerals

Figure: 5-3

5.2.6.2 Ghost Bat

A recent review of Ghost bat (Bat Call WA 2021a) updates the knowledge base on ecology, threats, and survey requirements for the species.

Ghost bats move between a number of caves seasonally or as dictated by weather conditions and/or foraging opportunities, so they require a range of cave sites (Richards *et al*. 2008). They disperse widely when not breeding but may concentrate in relatively few roost sites when breeding. In the Pilbara, except for the large abandoned mine colonies, ghost bats are often present either singly or in small groups (usually less than 15). These have been shown to move periodically, either seasonally or as dictated by prey availability. Their vagrant foraging strategy relates to patchy, locally unreliable rainfall events (and prey biomass) across much of its foraging habitat in the Pilbara and elsewhere in other semi-arid parts of its broader Australian range. Hence the relatively small groups that must move from roost to roost to access their ephemeral patchy food resource.

Extensive survey activity in the last decade has led to the proposal of 4 categories of roosting habitat used by ghost bats in the Pilbara region (Bullen 2021):

- Category 1 maternity/diurnal roost sites with permanent ghost bat occupancy;
- Category 2 maternity/diurnal roost caves with regular occupancy;
- Category 3 diurnal roost caves with occasional occupancy; and
- Category 4 nocturnal roost caves with opportunistic usage.

Within the Study Areas there are no Category 1, 2, 3 or 4 sites/caves available to this species.

In the Pilbara, Ghost bats prefer to forage on productive plain areas with thin mature woodland over patchy or clumped tussock or hummock grass (*Triodia spp.*) on sand or stony ground. Isolated trees and trees on the edge of thin thickets on the plains, or trees along the edges of watercourse woodlands, appear to be preferred vantage points (Bullen unpublished data). In the Study Areas there are scattered *Corymbia hamersleyana* and *Eucalyptus camaldulensis* trees available for perching.

No Ghost bats were recorded during the acoustic survey, however acoustic recorders are not suited to Ghost bat detection during foraging as the species seldom uses its echolocation away from caves.

The Ghost bat is listed in the PMST as known to occur within the local area and the DBCA database has records for the species within a 30 km radius. Ghost bats are known to travel up to 15 km from a roost site for foraging and up to 30 km in one night to alternative roosting sites, indicating the Study Areas may be within range of Category 1, 2 or 3 roosts.

It is possible that the Study Areas offer foraging habitat to Ghost bat across all habitats.

5.2.6.3 Pilbara Leaf-Nosed Bat

A recent review of Pilbara leaf-nosed bat (Bat Call WA 2022) updates the knowledge base on ecology, threats, and survey requirements for the species. It is generally encountered in rocky areas that provide opportunity for roosting, in particular the ironstone Hamersley Range, the ridgelines granite boulder piles and disused mines of the eastern Pilbara, and also along medium and major drainage lines that radiate away from rocky uplands.

Pilbara leaf-nosed bat roost during the day beyond the twilight zone in caves and underground mines with stable, warm and humid microclimates because of its poor ability to maintain its heat and water balance (Churchill *et al*. 1988; Jolly 1988; Churchill 1991; Baudinette *et al*. 2000; Armstrong 2001). There is a possibility that some roosts exist in the deeper spaces amongst granite tor rockpiles in the eastern Pilbara, (Armstrong and Anstee 2000; Armstrong 2001) although recent survey work is yet to identify any (Bat Call WA 2022). The Pilbara leaf-nosed bat does not roost in overhangs (shallow structures where the rear wall can be observed from the entrance), as these do not support warm, humid microclimates (TSSC, 2016). A suggestion that this species becomes 'forest dwelling' in the wet season of the monsoonal northern areas (Churchill 1991, 1995) has not been supported, and is very unlikely in the Pilbara region (Armstrong 2001).

Roosts have been categorised according to importance to the survival of the species into four categories (TSSC 2016):

- Category 1 - Permanent diurnal maternity roosts where seasonal presence of young is proven;
- Category 2 - Permanent diurnal roosts where presence of young is unproven;
- Category 3 - Semi-permanent diurnal roosts; and
- Category 4 - Nocturnal refuge.

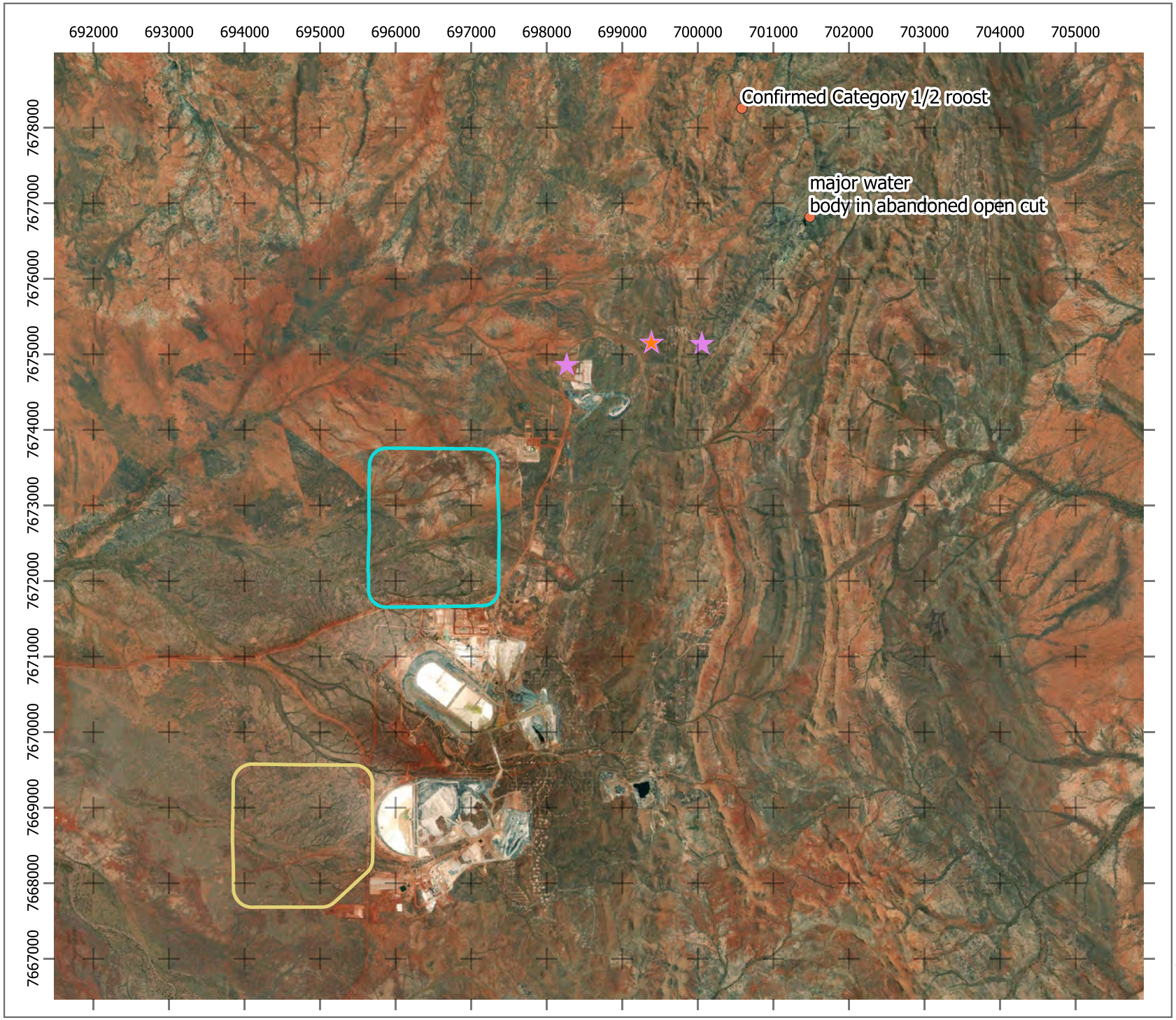
The Pilbara leaf-nosed bat was recorded locally during Targeted survey for individuals and roosts for the Pilgangoora Project (360 Environmental 2015, 2016). A Category 1 or 2 roost was located, and high-quality foraging habitat was identified at a major water body in an abandoned open cut pit. The roost site and confirmed foraging habitat are 5.5 km from the Study Areas to the northeast and are shown in Figure 5-4. An estimate of the number of Pilbara leaf-nosed bat at the roost based on ultrasonic calls and video counts ranged between 25-50. There are additional known permanent diurnal category 1 or 2 Pilbara leaf-nosed bat roosts approximately 20 km to the southwest and southeast of the Study Areas (Bat Call WA 2022).

Generally, the Pilbara leaf-nosed bat is most encountered within 20 km of its permanent diurnal roosts (Bullen 2013), but in the months where climatic conditions are least challenging for the species (April-May) they have been recorded further afield (Bat Call WA 2022). Echolocation based records indicate that it can complete round trips of 50 km or longer in a night under favourable conditions (Bat Call WA 2022).

The Study Areas do not contain any roosts described as Category 1, 2, 3 or 4. The Study Areas are within range of three Category 1/2 roosts.

Pilbara leaf-nosed bat was not recorded during acoustic survey within the Study Areas.

Habitat types found in the Pilbara have been scaled and a foraging habitat rating applied (Bat Call WA 2022). Habitats in the Study Areas conform to the description of *Open plain with one layer of vegetation structure (excluding scattered trees).* These are of low habitat rating. Pilbara leaf-nosed bat are unlikely to forage in the Study Areas but may traverse while crossing to more productive areas.



Legend

- TSF Option 2
- TSF Option 5
- Pilbara leaf-nosed bat database record
- Pilbara leaf-nosed bat acoustic records APM (2022)

Scale: @ A4
1: 70,000

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator

Author: EH Approved: ML Date: 02/11/2022

Pilbara leaf-nosed bat

Prepared for:
Pilbara Minerals

Figure: 5-4

5.2.6.4 Grey Falcon

The Grey falcon occurs in most of the drier parts of Australia (Schoenjahn 2018). Its distribution is centred on inland drainage systems where there is an average annual rainfall of less than 500 mm. Its main habitat is timbered lowland plains, particularly Acacia shrublands that are crossed by tree-lined watercourses. It generally occurs at low densities across inland Australia (BirdLife International 2019).

The Grey falcon hunts far out into tussock grassland and open woodland. It nests in old nests made by other birds, usually nests in the tallest trees along watercourses, particularly river red gum (TSSC 2020). Prey species include doves, pigeons, small parrots and cockatoos, and finches, but a variety of other bird prey species has been recorded, as well as mammals and lizards (TSSC 2020).

Local records are centred on the Turner River and major tributaries. The closest record is 10 km from the Study Areas to the southeast. The Study Areas are suitable foraging habitat for this species, and within range of the population likely to be nesting in the Turner River riparian zone. There are river red gum present in small patches in the Study Areas, however they are too small to provide nesting opportunities.

5.2.6.5 Night Parrot

The Study Areas are within the area where Night parrot is modelled as *may occur*. Very limited information is available on the Night parrot, however some information on habitat characteristics where the species has persisted is available.

DBCA (2017) summarises habitat characteristics. Night parrot roosting and nesting sites are in clumps of dense vegetation, primarily old and large spinifex (*Triodia*) clumps, but sometimes other vegetation types. Often the vegetation in these habitats will be naturally fragmented and therefore well protected from fire. Little is known about foraging sites, but favoured sites are likely to vary across the range of the species. In Queensland, Night parrots have been shown to feed in areas rich in herbs including forbs, grasses and grass-like plants, and it is likely that such areas may also be important in WA. *Triodia* is likely also to provide a good food resource for Night parrot, in times of mass flowering and seeding, but they also rely heavily on a range of other food species. *Sclerolaena* has been shown to be a source of food and moisture.

The species and growth pattern of the spinifex in some of the FH1 habitat in the Study Areas may be suitable for the Night parrot. There are no samphire or chenopod habitats proximal to the Study Areas, however the gilgai may seasonally support a diversity of herbs and other potential forage species. Night parrots have been known to fly up to 40 km or more in a night during foraging expeditions, so foraging habitat is not necessarily within or adjacent to roosting areas.

An interim guideline for preliminary surveys of Night parrot in WA (DPAW 2017) identifies when and where Night parrot surveys may be required. The Study Areas are on the north-western edge of the area classed as a high priority for survey. Due to the inclusion of the site in the high priority survey area and the presence of potentially suitable spinifex habitat, passive acoustic survey was conducted at locations where the best spinifex habitat was found. Four devices were deployed for a total of five trap nights. No Night parrot calls were recorded.

Foot traverses through the FH1 habitat where the largest and oldest hummock grasses occur did not encounter any signs of individuals of Night parrot.

While the habitat is potentially suitable, there are no historic records of Night parrot in the area and very few records of extant individuals. While it remains possible that the species could colonise in the future there is no evidence that they are currently present.

5.2.6.6 Greater Bilby

Extant populations of bilby occur in a variety of habitats, usually on landforms with level to low slope topography and light to medium soils (typically sandy for burrow excavation). Bilby occupies three major vegetation types; open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (Southgate 1990). Laterite and rock feature substrates are an important part of Greater bilby habitat, which support shrub species such as Acacia, and spinifex hummocks which are quite uniform and discrete, providing runways between hummocks, enabling easier movement and foraging (Southgate *et al.* 2007).

The species is identified by the PMST as known to occur within 30 km of the Study Areas. Database results returned 41 records within a 30 km radius of the Study Areas, the closest being one record to the east of Pilgangoora made in 1979. Recent records are from surveys conducted for the rail corridors that pass the Study Areas to the west.

Suitable habitat occurs in the Study Areas across the undulating plains habitat. Extensive foot transects were walked across these habitats at 10-20 m intervals. No burrows were located. Indeterminate signs were recorded in one location within Option 2. Scratchings were recorded as shown in Plate 5-1. The scratchings lacked attributes common to digging lizards and other species expected to occur. Large galls were also found in the location that appeared to have been broken open to retrieve the insect inside (Plate 5-2). Whilst there is no certainty these signs were left by bilby, and no commonly accepted understanding of bilby eating gall forming larvae, there is insufficient evidence to discount the possibility of bilby occurrence.

This species has the potential to occupy the Study Areas as bilbies can be relatively transient across their distribution. No burrows were observed suggesting any recent use may be for foraging only and transitory in nature.



Plate 5-1. Digging beneath an Acacia shrub, with galls beside the hole

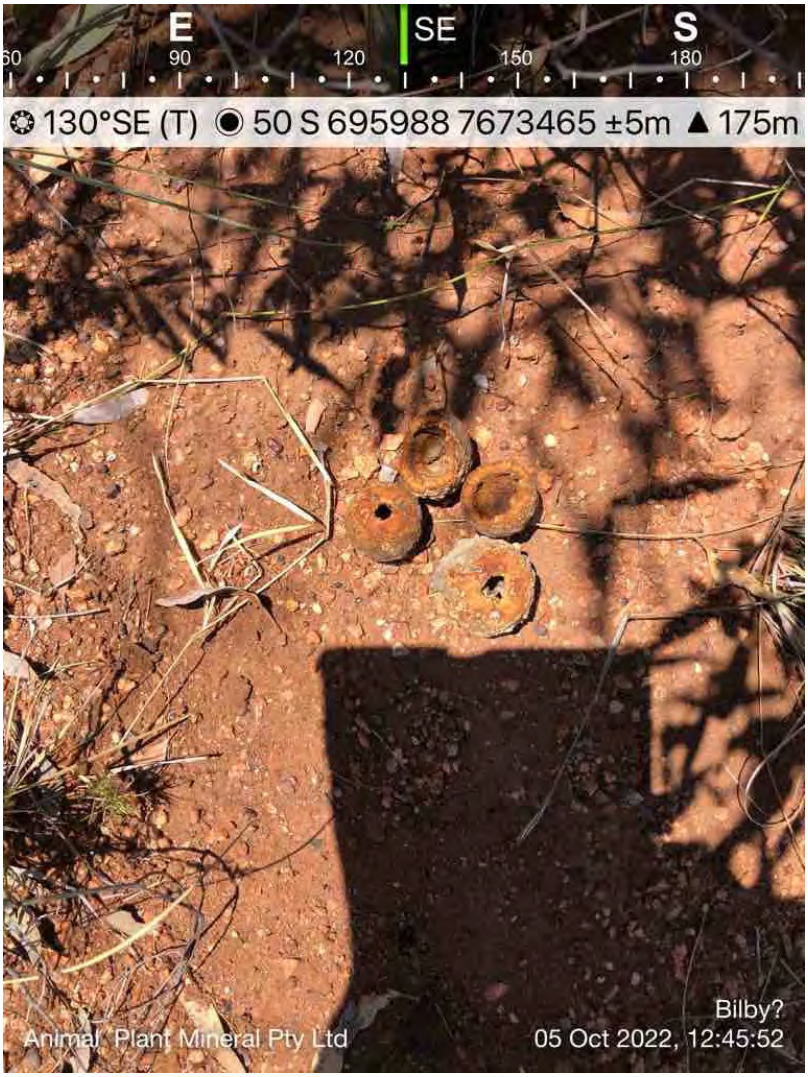


Plate 5-2. Galls broken open

5.2.6.7 Western Pebble Mount Mouse

The Western pebble-mound mouse is endemic to the Pilbara where it is found on stony hillsides with hummock grassland (Menkhorst and Knight, 2010). This species builds pebble mounds from small stones, which typically cover areas from 0.5-9.0 m^2. The mounds are characteristic of the species. Pebble mounds are restricted to areas with suitable class stones and are usually found on gentle slopes and spurs that are often vegetated by hard spinifex (Van Dyck and Strahan 2008). Active mounds are characterised by the conical shape of the mound with clear, distinct entrance holes (Anstee 1996). Mounds are often sited close to narrow ribbons of Acacia dominated scrub that grow along incised drainage lines (Van Dyck and Strahan 2008).

Targeted searches were performed using foot transects in suitable habitat. Thirteen mounds were recorded. The status of mounds was assessed according to the method published in Anstee (1996). The Anstee (1996) index is most accurate at predicting the status of mounds with very high (classed as active) or very low (classed as inactive) scores. Mounds with intermediate activity could be either active or inactive, depending on whether they are in the process of being activated or degrading following abandonment. Mound locations and status are listed in Table 5-4.

Table 5-4. Western Pebble-mound Mouse mound status and location

Status	Location (GDA 1994; MGA zone 50)
Active	695778, 7673491
Active	695859, 7673449
Active	695950, 7673431
Active	695146, 7668064
Active	693972, 7668364
Intermediate	695116, 7668632
Intermediate	696824, 7673506
Intermediate	696567, 7673489
Intermediate	695750, 7673481
Inactive	695118, 7668689
Inactive	696727, 7673495
Inactive	695820, 7673452
Inactive	696030, 7673419

5.2.6.8 Brush-tailed Mulgara

Brush-tailed mulgara is widespread, but patchily distributed in sandy regions of arid central Australia and WA. It inhabits hummock grass plains, sand ridges, and mulga shrubland on loamy soils (Menkhorst and Knight, 2010). It uses the open space between vegetation, a microhabitat that is known to support important prey species and may forage in termite mounds (Molyneux *et al*. 2018).

The Brush-tailed mulgara constructs burrows or utilises those of other species. Burrows may provide access to prey items, protection from predators and have thermoregulation benefits (Molyneux *et al*. 2018).

Local records are to the west of the Study Areas with the closest records 15 km to the southwest. Records originate from biological surveys assessing the impact of rail lines servicing the Pilbara region.

Suitable habitat occurs in the sandy areas of the undulating plain, however the preferred sand dune habitat is not present.

Targeted searches were conducted in suitable habitat for signs (tracks and burrow entrances) of the Mulgara. One location was marked where connected burrows appeared to be present. These were highly degraded and collapsed, indicating they are not currently in use, but may have once been occupied by Mulgara. Based on somewhat limited habitat, in that sandy rises are infrequently occurring, and the indication of an abandoned burrow, the Mulgara is considered as possibly occurring in the Study Areas.

5.2.6.9 Spectacled Hare-wallaby (mainland)

The Spectacled hare-wallaby inhabits tropical tussock or hummock grassland with mid-dense or sparse tree and shrub cover (Menkhorst and Knight, 2010). In the Pilbara this species has declined drastically, possibly due to fox predation and because frequent burning of spinifex grassland has prevented the development of the large hummocks required for shelter (Van Dyck and Strahan 2008).

There are many local records, in the surrounding foothills and plains habitats. These records are from the early 1990's.

No signs or records of Spectacled hare-wallaby were made in the Study Areas, despite targeted searches for individuals or signs (*e.g.* scats), motion triggered camera deployment and spotlighting. The species was not recorded during the detailed and reconnaissance fauna surveys for the Pilgangoora Project (360 Environmental 2016) or the Lynas Find extension (APM 2022). The absence of the species is likely a consequence of the broader regional decline.

Historic records indicate it is possible for the species to occur, however the habitat does not provide the shelter that would be required to persist under predation. The lack of shrubland indicates the quality of the habitat is poor.

5.2.6.10 Migratory birds

The undulating plains may provide seasonally available habitat to migratory birds including threatened species such as the Curlew sandpiper and Eastern curlew. The habitat does not contain preferred habitat for these species, and it is likely that due to the proximity to the more preferred habitats available on the coast, the value of these habitats is low. The Study Areas are not within or near to any locations where nationally or internationally significant aggregations occur.

6 CONCLUSIONS

6.1 FLORA

The flora and vegetation survey recorded a total of 123 taxa within the Study Areas which is comparable to the number of taxa recorded in other previous local surveys: 116 taxa (63 genera from 26 families) recorded by APM (2022) at the Lynas Find Deposit; 195 taxa (101 genera and 39 families) recorded by MMWC Environmental (2016) at the Pilgangoora Project, and 122 taxa (67 genera and 38 families) recorded by Outback Ecology (2009) at Wodgina.

The flora and vegetation of the Study Areas is generally typical of the Pilbara, and of the adjacent lands surrounding the Study Areas.

6.2 FLORA OF CONSERVATION SIGNIFICANCE

No T or P flora was recorded in the Study Areas.

One P3 species *Triodia chichesterensis* was previously recorded within the Option 2 area. It can be difficult to distinguish from *Triodia lanigera* outside of the northern part of the range. *Triodia lanigera* was common in the Study Areas and it is likely that *Triodia chichesterensis* is present in the stony rise areas where quartzite is present.

An additional eight species were determined to be possibly occurring or likely to occur based upon the availability of suitable habitat. Of these, one is a perennial shrub and would therefore have been present at the time of survey. The remaining seven are annual herbs or small herbaceous perennials that may not have been present due to seasonal conditions.

6.3 INTRODUCED FLORA

No weeds Declared under the BAM Act or classed as WoNS were recorded in the Study Areas. Six weeds were recorded, two species of agricultural grasses in the genus *Cenchrus* and the environmental weed Kapok were the most commonly recorded. *Cenchrus* grasses are valued by pastoralists and as the underlying land use is pastoralism it is not unexpected to record these weedy grasses. Whilst not being attributed any formal classification under weed management legislation, *Cenchrus* grasses are known to adversely alter fire regimes, which is a threatening process for some T fauna in the region.

Weeds were predominantly recorded in the creek habitats.

6.4 VEGETATION OF CONSERVATION SIGNIFICANCE

There are no recognised TECs, PECs or ESAs located within or adjacent to the Study Areas.

None of the vegetation types described for the Study Areas are analogous to any known TECs or PECs. The nearest record of a TEC or PEC to the Study Areas is the Gregory Land System (P3 PEC), approximately 50 km away from the Study Areas.

The Chichester Subregion includes seven Ecosystems at Risk which are subject to a range of threatening processes (Kendrick and McKenzie 2001). None of these ecosystems are relevant to the Study Areas.

Two species that have been associated with GDEs were recorded in the vegetation type 13a. The Bureau of Meteorology GDE Atlas indicates the Study Areas have a low likelihood of dependency. The red gum and coolabah within the 13a vegetation type are of low height and stem diameter, likely to be a consequence of intermittent water availability, supporting the assessment of a low likelihood of access to groundwater.

Regional Vegetation Associations within the Study Areas as described by Beard have over 99% pre-European Vegetation extent remaining. Conservation significance ranking of vegetation associations occurring within the Study Areas are of 'Least Concern'.

6.5 FAUNA OF CONSERVATION SIGNIFICANCE

The survey recorded multiple active Pebble mound mouse mounds. The Pebble mound mouse is known to occur in the area and its presence within the Study Areas is confirmed. The suitability of mound building habitat is confined by the availability of suitable size pebbles, which occur on the higher rises.

The Northern quoll is known to occur in the local area and critical habitat has been identified in the ridgeline to the east of the Study Areas. The Study Areas are more than 1 km from this critical habitat. The Study Areas contain habitats that are of possible value to the Northern quoll for foraging and dispersal however, they are of low quality. No signs of the Northern quoll were recorded and no captures on cameras were obtained. It is possible the Northern quoll occasionally uses the Study Areas however, they do not constitute critical habitat.

The Pilbara leaf-nosed bat is known to occur in the local area and diurnal roosts occur within the range of the Study Areas. The quality of habitat for the Pilbara leaf-nosed bat is limited to low quality foraging– the species may occasionally use the site for foraging or in transit to other more productive areas.

The Ghost bat is known to occur in the local area and diurnal roosts are known to occur within range of the Study Areas. The Study Areas are suitable foraging habitat for the Ghost bat. The Ghost bat was not recorded during the acoustic survey however the method has limitation with detection of the species. The species is likely to occur within the Study Areas, for foraging purposes only.

The Grey falcon is known to occur in the local area and the Study Areas are within foraging range of the species. Grey falcon nesting in the Turner River area are likely to visit the Study Areas at some times for the purpose of foraging.

During periods of inundation, the Study Areas are likely to sustain habitat suitable for migratory shorebirds. The quality of the habitat is likely to be lower than those available in the near coastal areas, as reflected in the lack of records from the site and immediate surrounds. There are no nationally or internationally significant aggregations of migratory species known to occur within or near the Study Areas.

An abandoned burrow that may once have hosted Brush-tailed mulgara was recorded. The burrow was collapsed, however there were indications of a multi-entranced burrow system as used by the Brush-tailed mulgara. Suitable habitat is limited to the sandy rises that occur sporadically throughout the undulating plains. No further signs were recorded. Whilst the Study Areas are likely to contain suitable habitat, there is no evidence of the species being currently present.

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APPENDICES

APPENDIX A: CONSERVATION AND DECLARED CATEGORIES

Conservation categories for threatened species and communities protected under Federal legislation are defined under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Environment Protection and Biodiversity Conservation Regulations 2000* are listed in Tables A.1. and A.2.

Table A.1: Categories and definitions for threatened flora and fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

Conservation Category	Definition
Extinct	Taxa with no reasonable doubt that the last member of the species has died.
Extinct in the wild	Taxa known to survive only in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriated seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (E)	Taxa are not critically endangered; and are facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (V)	Taxa are not critically endangered or endangered; and are facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Conservation dependent (CD)	Taxa are the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or the following subparagraphs are satisfied: i) the taxa is a species of fish; ii) the taxa is the focus of a management plan that provides management actions necessary to stop the decline of, and support the recovery of, the taxa so that its chances of long term survival in nature are maximized; iii) the management plan is in force under a law of the Commonwealth or of a State or Territory; and iv) Cessation of the management plan would adversely affect the conservation status of the taxa. Fish includes all taxa of bony fish, sharks, rays, crustaceans, molluscs and other marine organisms, but does not include marine mammals/reptiles.

Table A.2: Definitions for Threatened Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999*.

Conservation Category	Definition
Critically endangered	If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

For Section 182 of the EPBC Act and 179 of the EPBC Act Threatened Ecological Communities and Native species are in the Critically Endangered, Endangered or Vulnerable category if they meet any of the criteria for the category mentioned in Table A.3:

Table A.3: Criteria for listing Threatened Species and Threatened Ecological Communities under the *Environment Protection and Biodiversity Conservation Regulations 2000*

Threatened Species				
Item	**Criterion**	**Category**		
		Critically Endangered	**Endangered**	**Vulnerable**
1	It has undergone, is suspected to have undergone, or is likely to undergo in the immediate future:	A very severe reduction in numbers	A severe reduction in numbers	A substantial reduction in numbers
2	Its geographic distribution is precarious for the survival of the species and is:	Very restricted	Restricted	limited
3	The estimated total number of mature individuals is: And: (a) Evidence suggests that the number will continue to decline at: or (b) The number is likely to continue to decline and its geographic distribution is:	Very low A very high rate Precarious for its survival	Low A high rate Precarious for its survival	limited A substantial rate Precarious for its survival
4	The estimated total number of mature individuals is:	Extremely low	Very low	low
5	The probability of its extinction in the wild is at least:	50% in the immediate future	20% in the near future	10% in the medium term future
Threatened Ecological Communities				
Item	**Criterion**	**Category**		
		Critically Endangered	**Endangered**	**Vulnerable**
1	Its decline in geographic distribution is:	Very severe	Severe	substantial
2	Its geographic distribution is: And the nature of its distribution makes it likely that the action of a threating process could cause it to be lost in:	Very restricted The immediate future	restricted The near future	limited The medium term future
3	For a population of a native species that is likely to play a major role in the community, there is a: To the extent that restoration of the community is not likely to be possible in:	Very severe decline The immediate future	Severe decline The near future	Substantial decline The medium term future
4	The reduction in its integrity across most of its geographic distribution is: As indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	Very severe Very severe	severe severe	substantial substantial
5	The rate of continuing detrimental change is: As indicated by	Very severe	severe	substantial

	(a) A rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is: or	Very severe	severe	serious
	(b) Intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	Very severe	severe	serious
6	A quantitative analysis shows that its probability of extinction, or extreme degradation over all its geographic distribution, is:	At least 50% in the immediate future	At least 20% in the near future	At least 10% in the medium term future

In Western Australia, the *Biodiversity Conservation Act 2016* (BC Act) provides for the statutory listing of Threatened Ecological Communities, under the categories listed in Table A.4.

Table A.4: Definitions and criteria for Presumed Totally Destroyed, Critically Endangered, Endangered and Vulnerable Ecological Communities. Department of Environment and Conservation (2013).

PD : Presumed Totally Destroyed
An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats **or** B) All occurrences recorded within the last 50 years have since been destroyed.
CR : Critically Endangered
An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. B) Current distribution is limited, and one or more of the following apply (i, ii or iii): i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).
En : Endangered
An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years); ii) modification throughout its range is continuing such that in the short term future (within approximately

20 years) the community is unlikely to be capable of being substantially restored or rehabilitated.
B) Current distribution is limited, and one or more of the following apply (i, ii or iii):
i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years);
ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes;
iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.
C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

VU : Vulnerable

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.
An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C):
A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.
B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.
C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

In Western Australia, possible Threatened Ecological Communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (Table A.4).

Table A.5: Definitions and criteria for Priority Ecological Communities Department of Environment and Conservation (2013).

P1: Priority One – Poorly-known ecological communities
Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two – Poorly-known ecological communities
Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three – Poorly-known ecological communities
(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four
Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
P5: Priority Five – Conservation dependent ecological communities
Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

In Western Australia, the Wildlife Conservation (Specially Protected Fauna) Notice 2018 and the Wildlife Conservation (Rare Flora) Notice 2018 have been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.

Categories of Threatened, Extinct and Specially Protected fauna and flora are listed in Table A.6.

The definition of flora includes algae, fungi and lichens. The definition of Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Table A.6: Conservation codes for Western Australian flora and fauna under the *Biodiversity Conservation Act 2016* (DBCA 2019).

Code	Conservation Category	Definition
Threatened species		
Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act). Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna. Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora. The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.		
CR	**Critically Endangered**	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
EN	**Endangered**	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora
VU	**Vulnerable**	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.
Extinct species		
Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.		

EX	**Extinct**	Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act). Published as presumed extinct under schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for extinct fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora.
EW	**Extinct in the Wild**	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.
Specially protected species		
Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection. Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.		
MI	**Migratory Species**	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
CD	**Species of special conservation interest (conservation dependent fauna)**	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
OS	**Other Specially protected species**	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Table A.7: Priority species under Western Australian *Biodiversity Conservation Act 2016*.

P1: Priority One – Poorly known taxa
Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
P2: Priority Two – Poorly known taxa
Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
P3: Priority Three – Poorly known taxa
Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
P4: Priority Four: Rare, near threatened and other taxa in need of monitoring
((a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

The management of introduced species in Western Australia is regulated through the *Biosecurity and Agriculture Management Act 2007* (BAM Act). The BAM Act seeks to establish a biosecurity regulatory scheme to prevent serious animal and plant pests from entering the State and becoming established, and to minimise the spread and impact of any that are already present within the State.

The list of declared pests is provided under the BAM Act. Declared animal and plant pests fall into three categories as Gazetted under the *Biosecurity and Agriculture Management Regulations 2013*. These categories are outlined in Table A.7.

Table A.8: Declared pests control categories as gazetted under the *Biosecurity and Agriculture Management Regulations 2013.*

Category	Description
C1 (Exclusion)	Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 (Eradication)	Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 (Management)	Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

References

Department of Biodiversity Conservation and Attractions (2019) Conservation Codes for Western Australian Flora and Fauna. Last updated 3 January 2019. Accessed 25/04/20. https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Conservation%20code%20definitions.pdf

Department of Environment and Conservation (2013). Definitions, categories and criteria for threatened and priority ecological communities. Accessed 25/04/20 https://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/definitions_categories_and_criteria_for_threatened_and_priority_ecological_communities.pdf

APPENDIX B: PMST SEARCH RESULTS

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 01-Nov-2022

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	13
Listed Migratory Species:	11

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	16
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	22
Key Ecological Features (Marine):	None
Biologically Important Areas:	1
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.		
Scientific Name	Threatened Category	Presence Text
BIRD		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
MAMMAL		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
PLANT		
Pityrodia sp. Marble Bar (G.Woodman & D.Coultas GWDC Opp 4)		
[88310]	Endangered	Species or species habitat known to occur within area
REPTILE		
Liasis olivaceus barroni		
Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area
Liopholis kintorei		
Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area overfly marine area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat likely to occur within area overfly marine area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis as Rostratula benghalensis (sensu lato)		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area

Extra Information

EPBC Act Referrals			[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Abydos Direct Shipping Ore (DSO) Project, Stage 2	2013/6985	Controlled Action	Post-Approval
Abydos Direct Shipping Ore Project	2012/6345	Controlled Action	Post-Approval
Additional Rail Infrastructure between Herb Elliott Port Facility and Cloudbreak Mine Site	2010/5513	Controlled Action	Post-Approval
Development of the Wodgina Direct Shipping Ore Project, Stage 2	2011/5975	Controlled Action	Post-Approval
Miralga Creek Project, Pilbara region, WA	2019/8601	Controlled Action	Post-Approval
North Star Hematite Project	2012/6530	Controlled Action	Post-Approval
North Star Magnetite Project	2012/6689	Controlled Action	Post-Approval
Panoram Copper-Zinc mine	2007/3310	Controlled Action	Completed
Roy Hill to Port Hedland Rail Line and Associated Infrastructure	2010/5424	Controlled Action	Post-Approval
Wodgina Direct Shipping Ore Project	2009/5167	Controlled Action	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Not controlled action			
Development of iron ore resources in eastern Pilbara region, including port at P	2004/1562	Not Controlled Action	Completed
Expansion of the Talison Minerals Storage Facility, Wodgina Mine	2008/4675	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
Pilbara Bulk Ore Transport System Project, WA	2016/7637	Not Controlled Action	Completed
Pilbara Transmission Project, Pilbara, WA	2018/8349	Not Controlled Action	Completed
Rail and Port Facilities	2001/474	Not Controlled Action	Completed
Sulphur Springs Copper-Zinc Mining Project, Pilbara Region, WA	2013/6899	Not Controlled Action	Completed
Wodgina Lithium Mine Expansion, Pilbara, NT	2018/8194	Not Controlled Action	Completed
Not controlled action (particular manner)			
Additional Rail Infrastructure	2012/6314	Not Controlled Action (Particular Manner)	Post-Approval
Atlas Boodarie Link Project, WA	2012/6506	Not Controlled Action (Particular Manner)	Post-Approval
Mine the Hercules Deposit under the Wodgina Direct Shipping Ore Project Stage 3	2013/6789	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
Mine the Hercules Deposit under the Wodgina Direct Shipping Ore Project ??? Stage 3	2013/6777	Referral Decision	Completed

Biologically Important Areas		
Scientific Name	Behaviour	Presence
Seabirds		
Ardenna pacifica		
Wedge-tailed Shearwater [84292]	Breeding	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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APPENDIX C: DETAILED FLORA AND VEGETATION SURVEY SITES

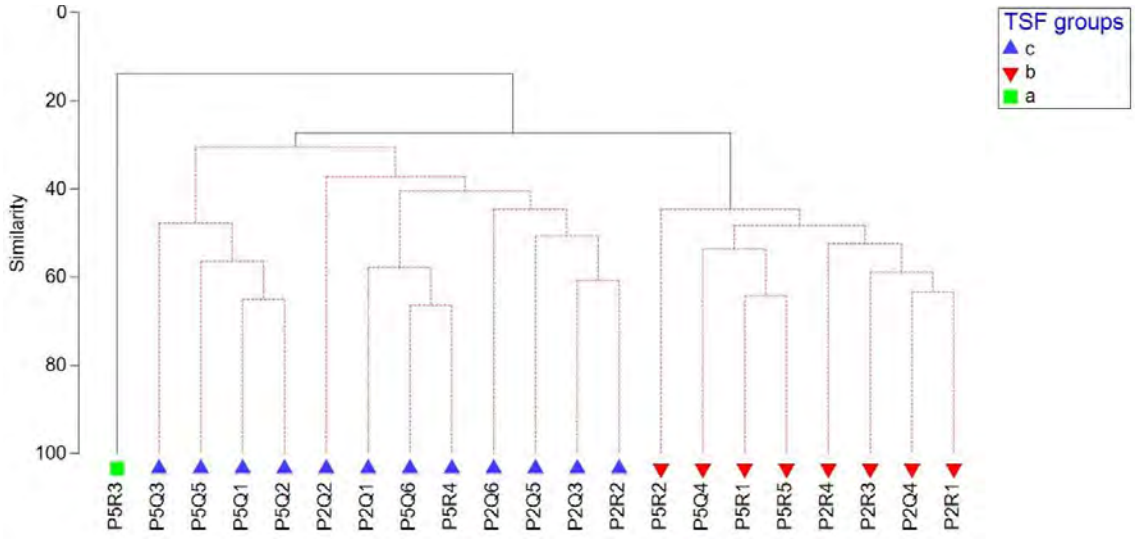
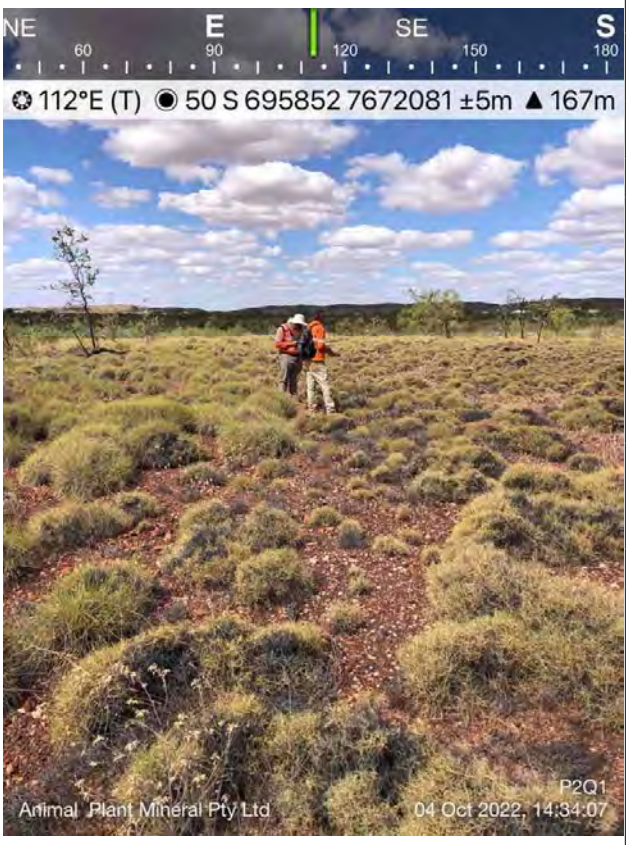


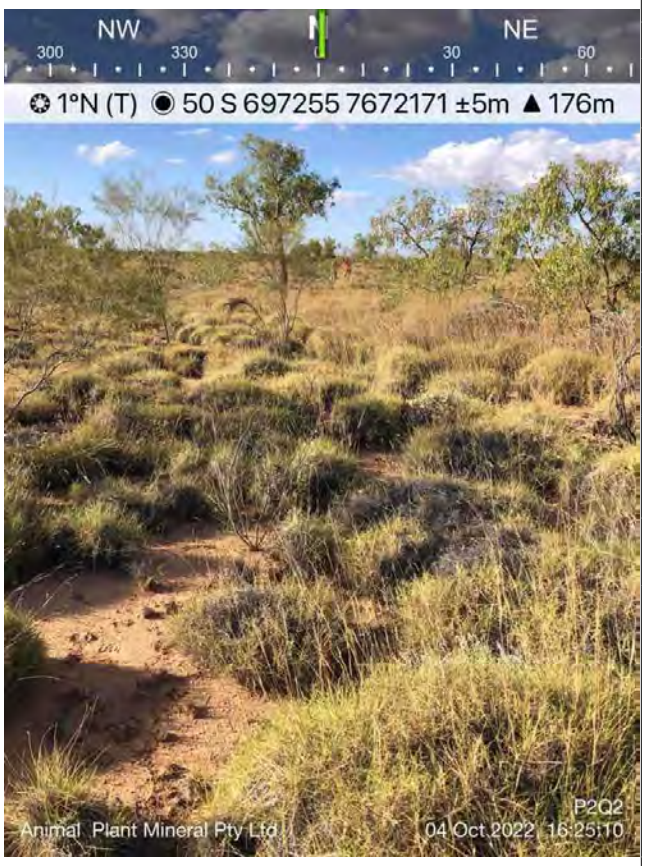
Figure C-1. Dendogram resulting from the cluster analysis of detailed vegetation sites

Job	PIL002
Site	P2-Q1
Date	4/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Quartz, ironstone, granite
Soil Type	Clay loam
Soil Colour	Red
Landform	Undulating plains
Surface Rocks Size	0.1 - 10 cm, angular
Surface Rocks Cover	70%
Slope aspect	-
Vegetation Description	Triodia bunch grassland with occasional Acacia small tree and isolated *Corymbia hamersleyana*
Condition/Disturbances	Good



Strata	Cover (%)	Height (m)	Species
Overstorey	1	4	*Corymbia hamersleyana*
Understorey	4.1	3	*Acacia tumida, Acacia adsurgens* and *Acacia inaequilatera*
Groundcover	45	0.8	*Triodia wiseana, Triodia epactia* and *Triodia lanigera*
Notes	Quadrat, 50 x 50 m		

Job	PIL002
Site	P2 - Q2
Date	4/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Granite, ironstone
Soil Type	Sandy loam
Soil Colour	Brown
Landform	Flat open plain
Surface Rocks Size	0.5 - 10 cm, angular
Surface Rocks Cover	80%
Slope aspect	Flat
Vegetation Description	Hummock grassland of Triodia *Triodia lanigera Triodia wiseana,* and *Triodia epactia* With emergent *Acacia tumida, Acacia bivenosa, Acacia orthocarpa* and isolated *Corymbia hamersleyana*
Condition/ Disturbances	Good



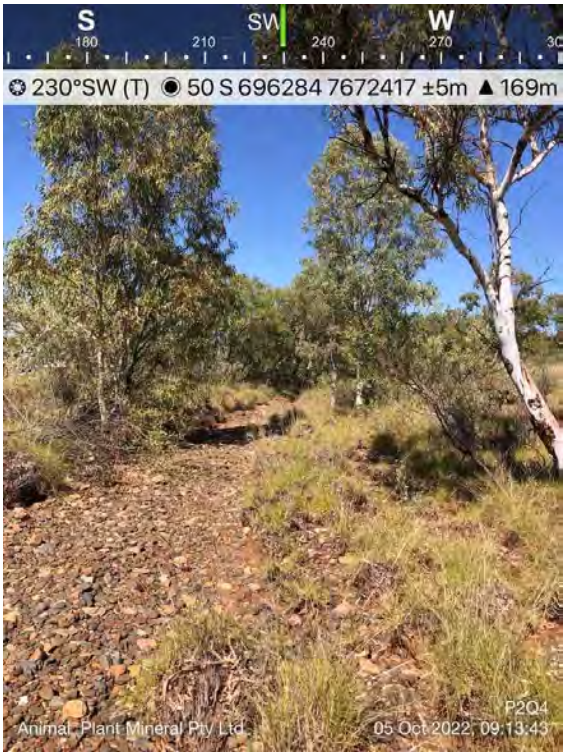
Strata	Cover (%)	Height (m)	Species
Overstorey	5	4	*Corymbia hamersleyana*
Understorey	2	0.6	*Acacia tumida, Acacia bivenosa, Acacia orthocarpa*
Groundcover	47	0	*Triodia lanigera Triodia wiseana,* and *Triodia epactia*
Notes	Quadrat, 50 x 50 m		

Job	PIL002
Site	P2 - Q3
Date	5/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Heavy dew, warm
Rock Type	Quartz, ironstone
Soil Type	Loamy
Soil Colour	Red
Landform	Upslope, 1st order drainage line
Surface Rocks Size	0.1 - 2 cm, angular
Surface Rocks Cover	20%
Slope aspect	Very gentle slope, channel to the east
Vegetation Description	Acacia shrubland with isolated Corymbia hamersleyana and Triodia hummock grassland
Condition/Disturbances	PIL002



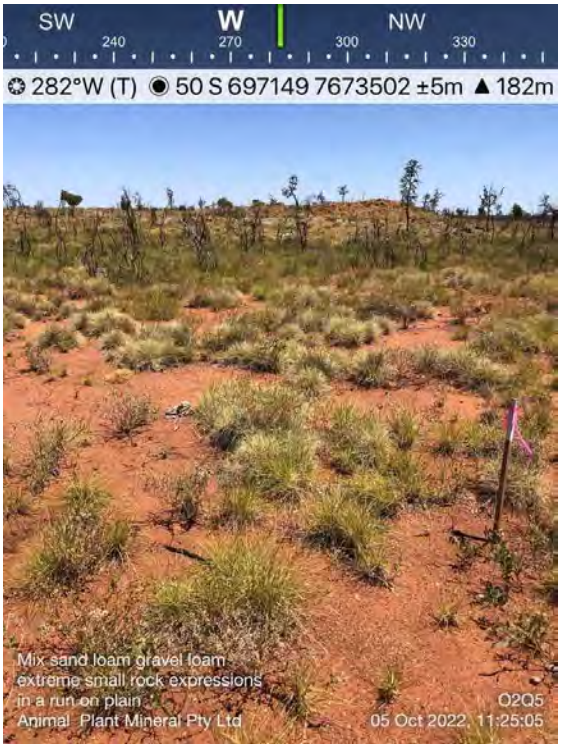
Strata	Cover (%)	Height (m)	Species
<1	4.5	<1	*Corymbia hamersleyana*
18	0.8	2.2	*Acacia tumida, A. adsurgens, A. inaequilatera*.
40	0.4	40	*Triodia lanigera. Triodia epactia, Triodia brizoides*
Notes	Quadrat, 50 x 50 m		

Job	PIL002
Site	P2 - Q4
Date	5/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	-
Seasonal Conditions	Warm, dry
Rock Type	Granite
Soil Type	Sandy loam
Soil Colour	Red
Landform	Secondary creekline (dry) ephemeral
Surface Rocks Size	1 - 10 cm, rounded
Surface Rocks Cover	In creek - 80%; on bank - 1%
Slope aspect	Gentle slope, east flowing
Vegetation Description	Open redgum woodland, sparse Acacia tall shrubland and Triodia hummock grassland
Condition	Good. Cenchrus and Kapok weeds. Moderate grazing.



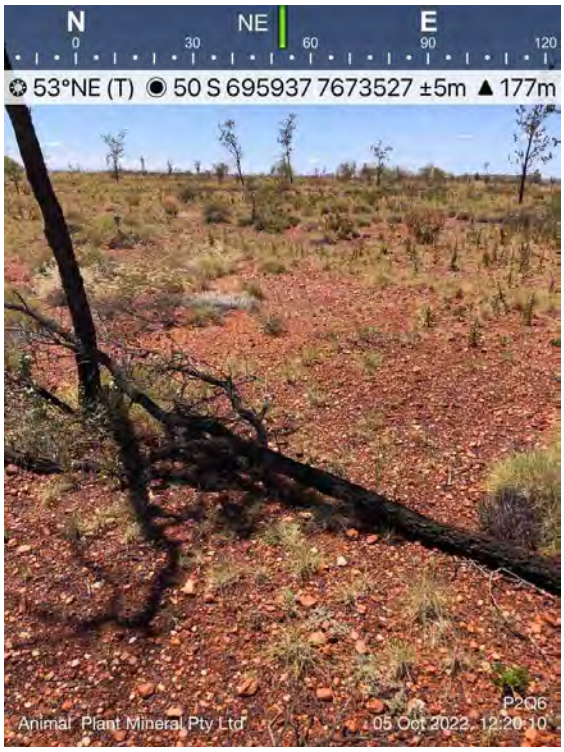
Strata	Cover (%)	Height (m)	Species
Overstorey	7	4	*Eucalyptus camaldulensis, Corymbia hamersleyana*
Understorey	9	2	*Acacia tumida, A. stellaticeps, Santalum lanceolatum*
Groundcover	41.1	0.8	*Triodia epactia, Triodia lanigera, Cenchrus ciliaris*
Notes	Quadrat, 25 x 100 m		

Job	PIL002
Site	P2 - Q5
Date	5/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	2 years
Seasonal Conditions	Dry, warm; dry soil
Rock Type	Schist, quartz
Soil Type	Sand
Soil Colour	Red
Landform	Undulating hillslope with some rock outcrops
Surface Rocks Size	1 - 15 cm, angular
Surface Rocks Cover	10%
Slope aspect	Slight slope to the east
Vegetation Description	Hummock grassland with some sparse Acacia shrubland and isolated C. hammersleyana - recovering from fire
Condition	Good



Strata	Cover (%)	Height (m)	Species
Overstorey	1	3	*Corymbia hammersleyana*
Understorey	10.9	1.5	*Acacia tumida, A. adsurgens, A. inaequilatera.*
Groundcover	16	0.2	*Triodia wiseana, T. epactia, T. lanigera*
Notes	Quadrat, 50 x 50 m Walking transect between P2 Q5 and Q6 indicated similar veg. community across the whole area		

Job	PIL002
Site	P2 - Q6
Date	5/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	2 years
Seasonal Conditions	Warm and dry soil surface
Rock Type	Schist, ironstone, quartz
Soil Type	Sandy loam
Soil Colour	Red
Landform	Flat stony plain
Surface Rocks Size	0.1 - 10 cm, rounded and angular
Surface Rocks Cover	70%
Slope aspect	Flat
Vegetation Description	Open hummock grassland of Triodia sp. with scattered tall *Acacia inaequilatera* recovering from recent fire
Condition	Good. Recovering from recent fire



Strata	Cover (%)	Height (m)	Species
Overstorey	-	-	
Understorey	2	3.5	*Acacia tumida, A. inaequilatera*
Groundcover	20	0.3	*Triodia lanigera, T. brizoides*.
Notes	Quadrat, 50 x 50 m		

Job	PIL002		
Site	P2 - R1		
Date	5/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dry, warm		
Rock Type	Granite, quartzite		
Soil Type	Loam sand		
Soil Colour	Red		
Landform	Ephemeral stream channel + riparian banks		
Surface Rocks Size	0.5 - 10 cm, rounded		
Surface Rocks Cover	In channel - 60%; Riparian banks - 5%		
Slope aspect	Very low slope flowing to the west		
Vegetation Description	Low Eucalyptus camaldulensis open woodland, sparse Acacia tall shrubland, Cenchrus tussock grassland.		
Condition	Good. Moderate Cattle grazing on stream banks. Cenchrus weeds,		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	6.5	5	*Eucalyptus camaldulensis, Corymbia hamersleyana*
Understorey	5.1	2.5	*Acacia tumida, A. bivenosa, A. stellaticeps*
Groundcover	30.3	0.6	*Cenchrus ciliaris, Triodia epactia, Cenchrus setiger*
Notes	Releve, 25 x 100 m		

Job	PIL002		
Site	P2 - R2		
Date	5/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	3 years		
Seasonal Conditions	Dry soil + warm		
Rock Type	Laterite, quartzite		
Soil Type	Loamy sand		
Soil Colour	Red		
Landform	Flat undulating rocky plain		
Surface Rocks Size	0.5 - 10 cm, angular		
Surface Rocks Cover	15%		
Slope aspect	Flat		
Vegetation Description	Sparse tall Acacia shrubland with Triodia open hummock grassland		
Condition	Very good		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey			
Understorey	7.3	3.5	*Acacia tumida, Acacia adsurgens* and *Acacia inaequilatera.*
Groundcover	25	0.3	*Triodia epactia, T. lanigera*
Notes	Releve, 50 x 50 m		

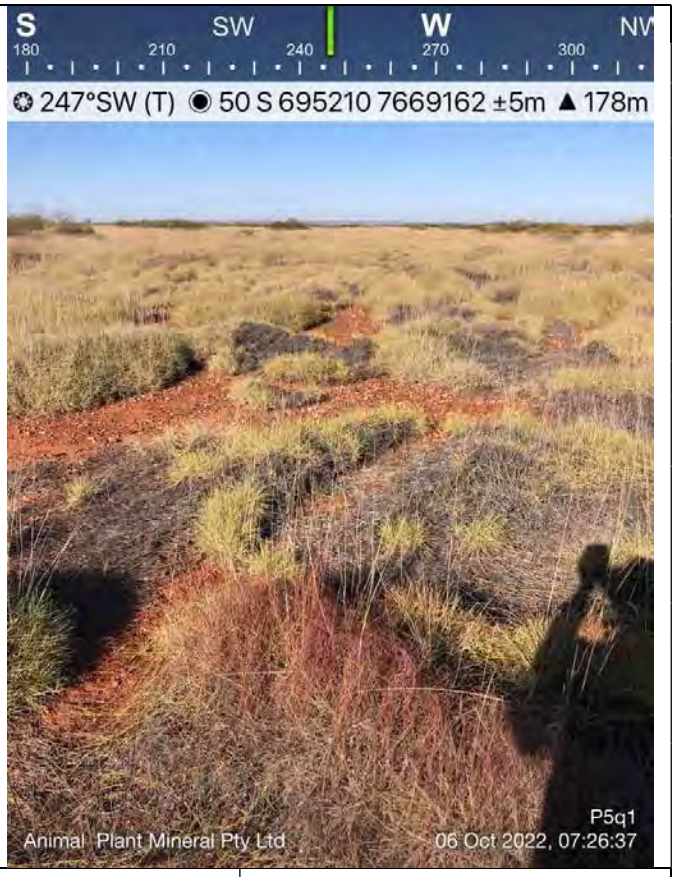
Job	PIL002		
Site	P2 - R3		
Date	5/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Warm, dry		
Rock Type	Granite, quartzite		
Soil Type	Sandy loam		
Soil Colour	Red		
Landform	Creekline and riparian banks of ephemeral creek; some surface water remaining (hence, heavily cattle use)		
Surface Rocks Size	0.5 - 10 cm, angular		
Surface Rocks Cover	Creekbed - 20%; Riparian banks - 2%		
Slope aspect	Very gentle slope to west (direction of flow)		
Vegetation Description	Isolated Eucalyptus/Corymbia low woodland, open Acacia mid shrubland, with Cenchrus tussock grass/ Triodia hummock grassland		
Condition	Good. Moderate grazing. Cenchrus weeds.		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	0.5	4	*Corymbia hamersleyana, Eucalyptus victrix*
Understorey	14	1.2	*Acacia tumida, A. stellaticeps, A. bivenosa*
Groundcover	32	0.6	*Cenchrus ciliaris, Triodia epactia, T. lanigera.*
Notes	Releve, 25 x 100 m		



Job	PIL002		
Site	P2 - R4		
Date	7/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dry, warm		
Rock Type	Granite		
Soil Type	Sand / loamy sand		
Soil Colour	Brown		
Landform	Ephemeral creekline + riparian banks		
Surface Rocks Size	0.1 - 15 cm, rounded		
Surface Rocks Cover	20%		
Slope aspect	Stream flow to the east		
Vegetation Description	Eucalyptus camaldulensis low open woodland, sparse Acacia tall shrubland with mixed perennial tussock grass understorey		
Condition	Good. Grazing, Cenchrus weeds.		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	10	4.5	*Eucalyptus camaldulensis*
Understorey	2	2	*Acacia tumida, A. stellaticeps, A. bivenosa*
Groundcover	16	0.8	*Triodia epactia, Cenchrus ciliaris and Themeda triandra*
Notes	Releve, 100 x 50 m		



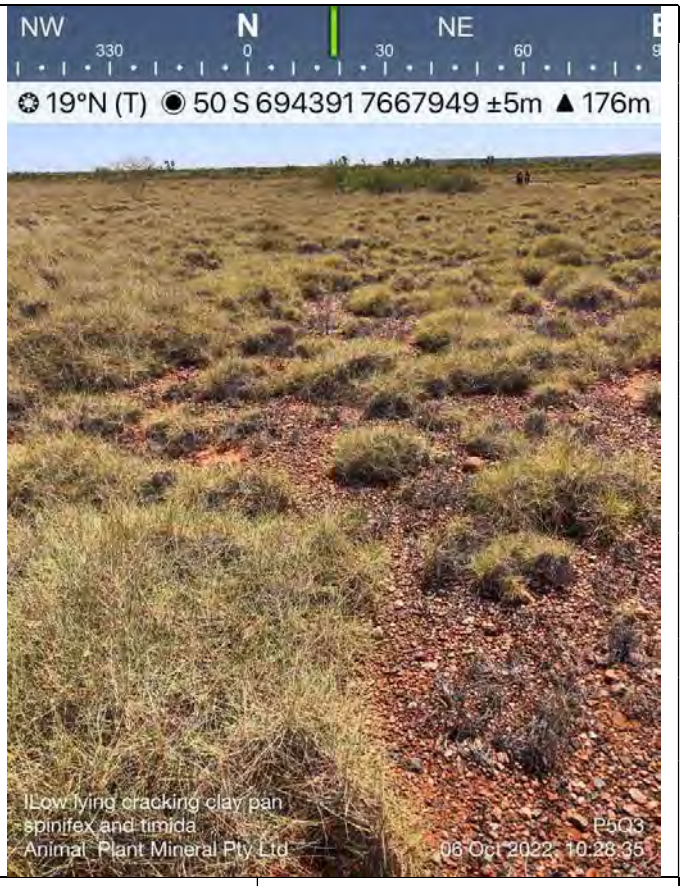
Job	PIL002
Site	P5 - Q1
Date	6/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Warm + dry
Rock Type	Quartzite, granite
Soil Type	Sandy loam
Soil Colour	Red
Landform	Flat plain; run on area with clay soil and gilgai terrain adjacent
Surface Rocks Size	1 -10 cm, angular
Surface Rocks Cover	60%
Slope aspect	Flat
Vegetation Description	Triodia Hummock grassland with tall, isolated Acacia spp. shrub
Condition	



Strata	Cover (%)	Height (m)	Species
Overstorey			
Understorey	6.5	2	*Acacia adsurgens* *Acacia bivenosa* *Petalostylis labicheoides*
Groundcover	70	1	*Triodia angusta, T. epactia*
Notes	Quadrat, 50 x 50 m		

Job	PIL002		
Site	P5 - Q2		
Date	6/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Warm, dry		
Rock Type	Granite, quartz		
Soil Type	Sandy loam, clay loam		
Soil Colour	Red		
Landform	Flat stony plain partly run on area with gilgia clay		
Surface Rocks Size	0.1 - 10 cm angular		
Surface Rocks Cover	40%		
Slope aspect	Flat		
Vegetation Description	Open Triodia hummock grassland with scattered Acacia mid shrubs.		
Condition	Very good		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey			
Understorey	5.6	1.5	*Acacia adsurgens, A. bivenosa, Petalostylis labichiodes.*
Groundcover	35	0.8	*Triodia angusta, T. lanigera, T. epactia*
Notes	Quadrat, 50 x 50 m Area from this Quadrat to NW corner was walked and the vegetation was uniform throughout (same as P5Q1, P5Q2) (See photos)		

Job	PIL002
Site	P5 - Q3
Date	6/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Quartzite, granite
Soil Type	Sany loam / loamy clay
Soil Colour	Red
Landform	Stony flat plain with interspersed clayey gilgai areas of around 10 m diameter
Surface Rocks Size	1 - 10 cm, angular
Surface Rocks Cover	40%
Slope aspect	Flat Gilgai area
Vegetation Description	Triodia Hummock grassland with sparse tall Acacia spp.;
Condition	Very good



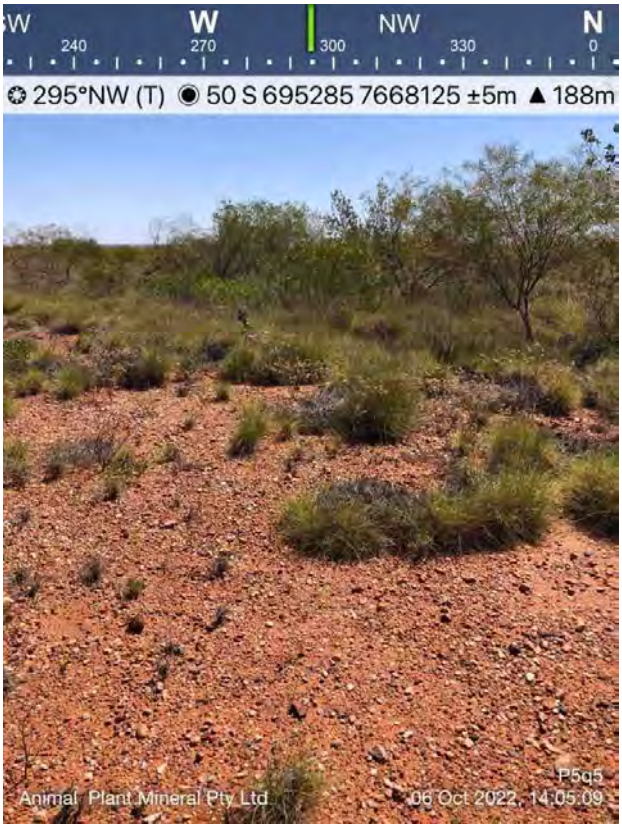
Strata	Cover (%)	Height (m)	Species
Overstorey			
Understorey	2.1	2	*Acacia adsurgens, A. bivenosa, Goodenia lamprosperma*
Groundcover	60	0.8	*Triodia brizoides, T. angusta, T. epactia*
Notes	Quadrat, 50 x 50 m		

Job	PIL002
Site	P5 - Q4
Date	6/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Granite, quartzite
Soil Type	Sandy loam
Soil Colour	Red
Landform	Ephemeral creek no riparian banks
Surface Rocks Size	0.1 - 1 cm, rounded
Surface Rocks Cover	5%
Slope aspect	-
Vegetation Description	Eucalyptus low open woodland; tall sparse Acacia shrubland, open hummock/tussock grassland.
Condition/Disturbances	Good, Extensive cattle grazing on banks, causing erosions on those banks. Cenchrus and Kapok.



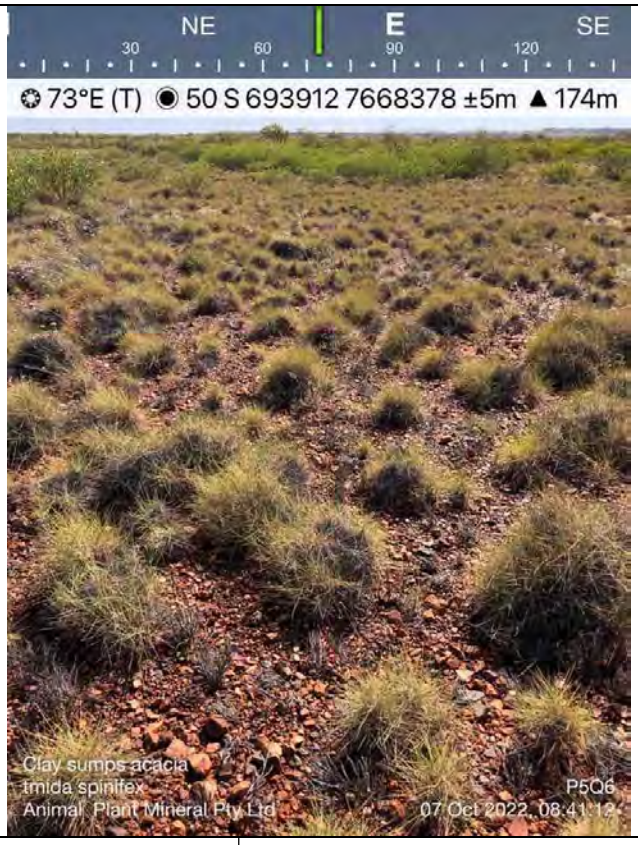
Strata	Cover (%)	Height (m)	Species
Overstorey	5	5	*Eucalyptus camaldulensis, Corymbia hamersleyana*
Understorey	4	2	*Acacia tumida, Acacia adsurgens, Acacia inaequilatera*
Groundcover	18.2	0.8	*Cenchrus setiger, C. ciliaris, Triodia epactia*
Notes	Quadrat, 25 x 100 m		

Job	PIL002
Site	P5 - Q5
Date	6/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Granite, quartzite
Soil Type	Loamy sand
Soil Colour	Red
Landform	Drainage depression in broad flat plain, no channel
Surface Rocks Size	0.1 - 10 cm, angular
Surface Rocks Cover	30%
Slope aspect	Slight west slope
Vegetation Description	Triodia hummock grassland with sparse tall Acacia shrubland
Condition	Good. Low level cattle grazing



Strata	Cover (%)	Height (m)	Species
Overstorey			
Understorey	8.5	3	*Acacia adsurges, A. tumida, Grevillea wickhamii*
Groundcover	49	0.8	*Triodia angusta, T. epactia, T. lanigera*
Notes	Quadrat, 50 x 50 m		

Job	PIL002
Site	P5 - Q6
Date	7/10/2022
Botanist:	Neil Pettit / Danah Blache
Age since fire	> 5 years
Seasonal Conditions	Dry, warm
Rock Type	Granite, quartzite
Soil Type	Loamy sand
Soil Colour	Red
Landform	Stony open flat plain
Surface Rocks Size	0.1 - 15 cm, angular
Surface Rocks Cover	75%
Slope aspect	Slight gradient to the North
Vegetation Description	Low Triodia hummock grassland with isolated tall Acacia shrubs
Condition	Very good



Strata	Cover (%)	Height (m)	Species
Overstorey			
Understorey	6	2.5	*Acacia tumida, A. adsurgens, Grevillea wickhamii*
Groundcover	45	0.4	*- Triodia wiseana, T. angusta*
Notes	Quadrat, 50 x 50 m		

Job	PIL002		
Site	P5 - R1		
Date	6/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dry, warm		
Rock Type	Calcrite		
Soil Type	Sandy loam		
Soil Colour	Red		
Landform	Ephemeral creekline and riparian area on		
Surface Rocks Size	1 - 20 cm, angular		
Surface Rocks Cover	20%		
Slope aspect	Very slow, no channel, invert flowing west		
Vegetation Description	Open low woodland of Corymbia hamersleyana sparse tall Acacia shrubs with Triodia/Cenchrus open tussock grassland		
Condition	Good. Moderate Grazing, weedy cenchrus and kapok		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	10	4.5	*Corymbia hamersleyana*
Understorey	2.3	2.5	*Acacia tumida, A. inaequilatera, Petalostylis cassioides*
Groundcover	21	1	*Triodia epactia, Cenchrus ciliaris, Cenchrus setiger*
Notes	Releve, 25 x 100 m		



Job	PIL002		
Site	P5 - R2		
Date	7/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dry, warm		
Rock Type	Granite, quartzite		
Soil Type	Sand / sandy loam		
Soil Colour	Red		
Landform	1st order ephemeral creek + riparian area		
Surface Rocks Size	0.1 - 15 cm, angular		
Surface Rocks Cover	Creekline - 60%; Riparian - 30%		
Slope aspect	Creek flows to the West		
Vegetation Description	Low open woodland of Corymbia hamersleyana, mid isolated Acacia shrubs , Triodia hummock grassland		
Condition	Good. Moderate grazing, Cenchrus weeds.		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	2	3.5	*Corymbia hamersleyana*
Understorey	1.5	1.3	*Acacia bivenosa, A. adsurgens, Petalostylis cassioides*
Groundcover	53	0.7	*Triodia angusta, Triodia epactia. Cenchrus ciliaris*
Notes	Releve, 25 x 100 m		



Job	PIL002		
Site	P5 - R3		
Date	7/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	1 year		
Seasonal Conditions	Warm, dry		
Rock Type	Granite, quartzite		
Soil Type	Loam		
Soil Colour	Red		
Landform	Stony flat open plain with 1st order drainage line		
Surface Rocks Size	0.1 - 10 cm, angular		
Surface Rocks Cover	30%		
Slope aspect	Very gently towards East		
Vegetation Description	Corymbia hamersleyana low open woodland with low sparse forbland (Degraded hummock grassland)		
Condition	Poor, high impact grazing, erosion, lacking a midstory, weedy grasses.		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	2	3.5	*Corymbia hamersleyana*
Understorey			
Groundcover	6	0.1	*Streptoglossa odora Goodenia lamprosperma, Solanum diversiflorum.*
Notes	Releve, 25 x 100 m		



Job	PIL002		
Site	P5- R4		
Date	7/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dusty		
Rock Type	Granite/cacrete		
Soil Type	Fine loamy sand		
Soil Colour	Red		
Landform	Stony undulating plain		
Surface Rocks Size	0.5 - 30 cm, angular		
Surface Rocks Cover	80%		
Slope aspect	Slight slope to the east		
Vegetation Description	Triodia hummock grassland with sparse tall acacia shrubland		
Condition	Very good		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey			
Understorey	6.5	3	*Acacia tumida, A. adsurgens, A. inaequilatera*
Groundcover	50	0.6	*Triodia wiseana, T. epactia*
Notes	Releve, 50 x 50 m		



Job	PIL002		
Site	P5 - R5		
Date	7/10/2022		
Botanist:	Neil Pettit / Danah Blache		
Age since fire	> 5 years		
Seasonal Conditions	Dry, warm		
Rock Type	Granite		
Soil Type	Sandy loam		
Soil Colour	Red		
Landform	1st order ephemeral creek + riparian area		
Surface Rocks Size	0.1 - 2 cm		
Surface Rocks Cover	5%		
Slope aspect	West flowing stream		
Vegetation Description	Corymbia hamersleyana low open woodland, tall isolated Acacia shrubs, Cenchrus tussock grassland		
Condition	Good. Heavy cattle grazing, invasion by exotic grasses		
Strata	**Cover (%)**	**Height (m)**	**Species**
Overstorey	5	4	*Corymbia hamersleyana*
Understorey	1.5	2	*Acacia tumida, A. bivenosa, A. inaequilatera*
Groundcover	40.2	0.5	*Cenchrus setiger, C. ciliaris, Triodia lanigera.*
Notes	Releve, 25 x 100 m		



APPENDIX D: FAUNA HABITAT PHOTOS


N NE E
330 0 30 60 90
36°NE (T) 50 S 695864 7672232 ±5m 173m
Creek line
Animal Plant Mineral Pty Ltd
As622904
04 Oct 2022, 14:27:25


NW N NE
300 330 0 30
349°N (T) 50 S 695421 7669235 ±5m 179m
Animal Plant Mineral Pty Ltd
Msc006
04 Oct 2022, 15:42:40

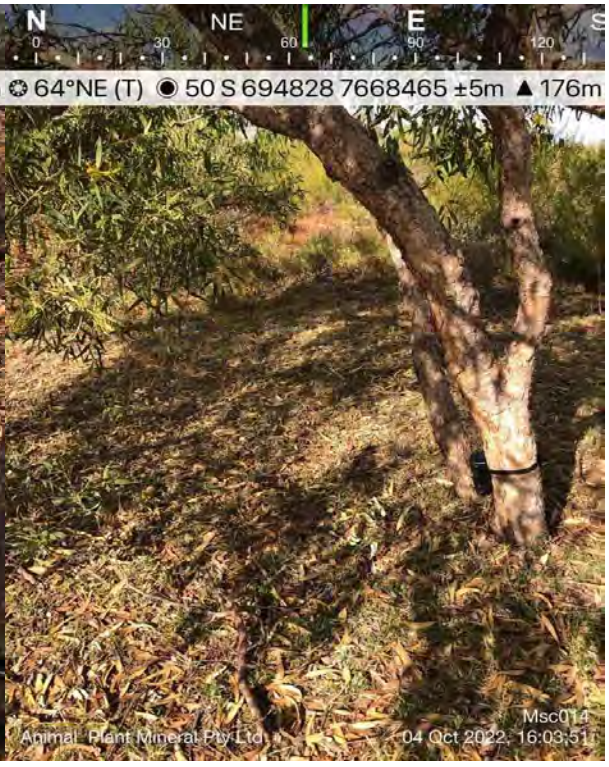

S W
180 210 240 270
223°SW (T) 50 S 695423 7668139 ±5m 187m
Animal Plant Mineral Pty Ltd
Msc007
05 Oct 2022, 15:51:14


NW N NE E
330 0 30 60 90
24°NE (T) 50 S 697421 7672050 ±5m 177m
DANGER
ACTIVE MINING AREA
NO UNAUTHORISED ENTRY
HEAVY EQUIPMENT OPERATING
Animal Plant Mineral Pty Ltd
Msc010
06 Oct 2022, 07:40:44


NE E SE
30 60 90 120 150
99°E (T) 50 S 696915 7671812 ±5m 178m
Move to rank creek
Animal Plant Mineral Pty Ltd
As660654
05 Oct 2022, 16:42:24


NE E SE
30 60 90 120 150
98°E (T) 50 S 697059 7673519 ±5m 188m
Low spinifex, some dense shrub. Stony soil
Animal Plant Mineral Pty Ltd
Msc011
05 Oct 2022, 10:20:43


W NW N
240 270 300 330 0
307°NW (T) 50 S 695614 7668304 ±5m 189m
Animal Plant Mineral Pty Ltd
Msc012
05 Oct 2022, 16:07:59


N NE E
0 30 60 90 120
64°NE (T) 50 S 694828 7668465 ±5m 176m
Animal Plant Mineral Pty Ltd
Msc014
04 Oct 2022, 16:03:51

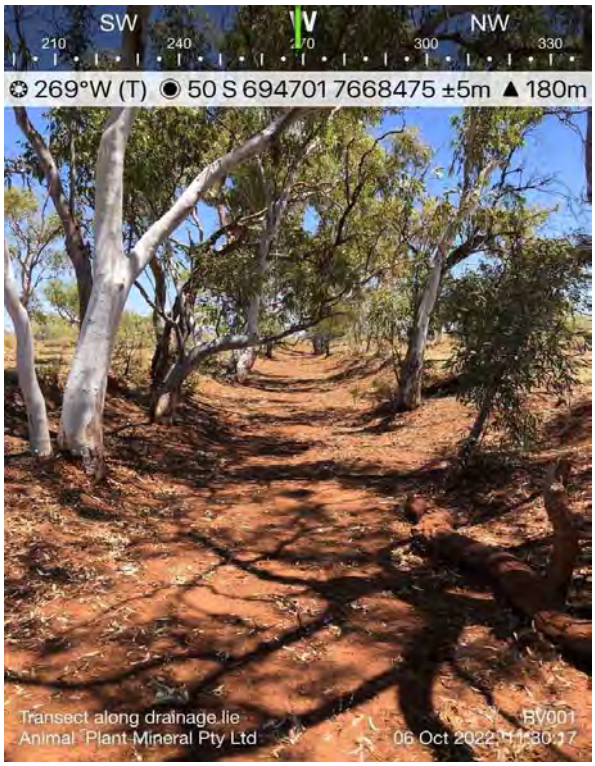

SW
W
NW
289°W (T) 50 S 695653 7673140 ±5m 168m
Msc016
Animal Plant Mineral Pty Ltd
05 Oct 2022, 07:13:59


S
SW
W
213°SW (T) 50 S 695424 7669227 ±5m 177m
Np001
Animal Plant Mineral Pty Ltd
04 Oct 2022, 15:46:35


NE
E
SE
81°E (T) 50 S 697352 7672088 ±5m 170m
NP002
Animal Plant Mineral Pty Ltd
04 Oct 2022, 14:55:00


W
NW
N
330°NW (T) 50 S 693852 7668141 ±5m 162m
Np003
Animal Plant Mineral Pty Ltd
04 Oct 2022, 15:57:52

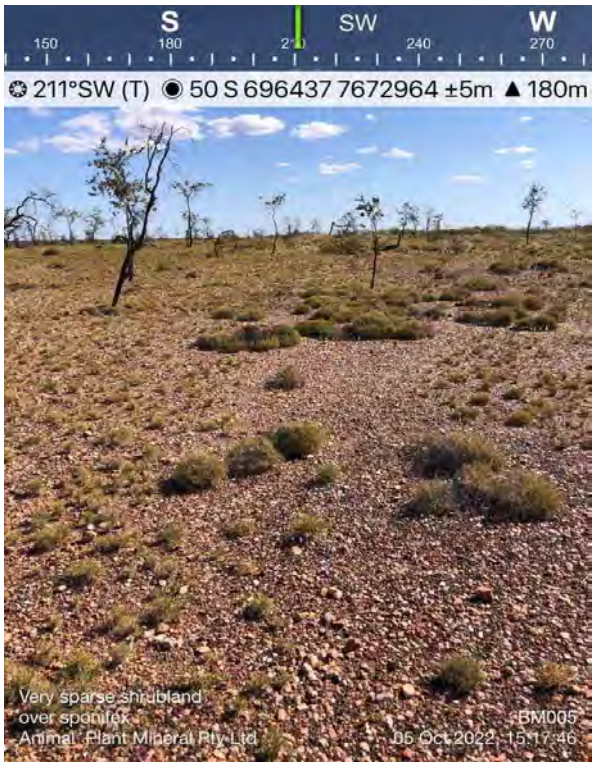

SE S SW
150 180 210 240
196°S (T) 50 S 695694 7673128 ±5m 167m
NP004
Animal Plant Mineral Pty Ltd
04 Oct 2022 15:05:44


SW W NW
210 240 270 300 330
269°W (T) 50 S 694701 7668475 ±5m 180m
Transect along drainage.lie
BV001
Animal Plant Mineral Pty Ltd
06 Oct 2022 11:30:17


NE E SE S
60 90 120 150
111°E (T) 50 S 696343 7672339 ±5m 171m
Low spinifex, some dense shrub. Stony soil
BM001
Animal Plant Mineral Pty Ltd
05 Oct 2022 09:21:38


E SE S
90 120 150 180 210
144°SE (T) 50 S 697161 7673637 ±5m 177m
Mix sand loam gravel loam
extreme small rock expressions
In a run on plain
BM002
Animal Plant Mineral Pty Ltd
05 Oct 2022 10:41:47


NE
30
60
120
150
SE
90°E (T) 50 S 695966 7673465 ±5m ▲173m
BM003
Animal Plant Mineral Pty Ltd
05 Oct 2022, 13:09:26


S
150
180
SW
240
W
270
211°SW (T) 50 S 696437 7672964 ±5m ▲180m
Very sparse shrubland
over spinifex
BM005
Animal Plant Mineral Pty Ltd
06 Oct 2022, 15:17:46


SE
150
S
180
SW
210
240
198°S (T) 50 S 695359 7669273 ±5m ▲176m
Not suitable. Crack clay low
lying. Flood prone
BM006
Animal Plant Mineral Pty Ltd
06 Oct 2022, 07:40:12


N
0
30
60
E
90
48°NE (T) 50 S 694639 7668965 ±5m ▲176m
Not suitable. Crack clay low
lying. Flood prone
BM007
Animal Plant Mineral Pty Ltd
06 Oct 2022, 08:04:26


S SW W
180 210 240 270 300
235°SW (T) 50 S 694448 7667899 ±5m 167m
Identical to BM006+7. Low lying cracking clay pan spinifex and timida
Animal Plant Mineral Pty Ltd
BM008
06 Oct 2022, 10:18:53


NE E SE
30 60 90 120
78°E (T) 50 S 693887 7668874 ±5m 174m
More elevated rolling Stoney hills interspersed with first order streams
Animal Plant Mineral Pty Ltd
BM009
06 Oct 2022, 11:51:02


W NW N
240 270 300 330 0
304°NW (T) 50 S 695031 7668085 ±5m 183m
Elevated slightly. Appears no clay sumps but very stony ground. Not suitable burrowing
Animal Plant Mineral Pty Ltd
BM010
06 Oct 2022, 14:09:19


NW N NE
300 330 0 30 60
354°N (T) 50 S 693860 7668195 ±5m 174m
Same clay sumps dense spinifex
Animal Plant Mineral Pty Ltd
Bm012
06 Oct 2022, 15:48:53

APPENDIX E: SPECIALISED ZOOLOGICAL TECHNICAL REPORT

Acoustic analysis and bat call identification from Lynas Find, Western Australia

Prepared for **Animal Plant Mineral Pty Ltd**

Version **23 November 2022**

SZ project reference **SZ637**



Prepared by **Dr Kyle Armstrong and Yuki Konishi**

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This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2022). Acoustic analysis and bat call identification from Lynas Find, Western Australia. Unpublished report by Specialised Zoological for Animal Plant Mineral Pty Ltd, 23 November 2022, project reference SZ637.

Summary

The outcome is provided of the analysis of acoustic (bat detector) recordings made at Lynas Find, in the Pilbara region of Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics.

The scope of the analysis was limited to the detection of the Threatened-listed Ghost Bat *Macroderma gigas* (Megadermatidae) and Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* (Rhinonycteridae). Attention was also given to determining if the Northern Leaf-nosed Bat *Doryrhina* (=*Hipposideros*) *stenotis* (Hipposideridae) was present based on an acoustics-based record as part of a previous biological survey (report and further details unavailable).

Acoustic processing of the bat detector recordings was conducted separately for each of these three species using methods optimised for the detection of their unique echolocation call types. The recording dataset comprised a total of 59 recording nights from four bat detector units (**Table 1**).

No calls of the Ghost Bat were observed in the recordings. There were many examples of insect stridulations that had some similarity to the structure of the echolocation call of the Ghost Bat (**Figure 1**), but the repetitive nature of these and the lack of any associated social calls of the Ghost Bat is evidence that the source is from an insect.

No calls of the Pilbara Leaf-nosed Bat were observed in the recordings. Five sequences of the Pilbara Leaf-nosed Bat were recorded in a recent survey in the same study area (Specialised Zoological 2022).

No calls of the Northern Leaf-nosed Bat were detected. The accepted distribution of this species does not include in the Pilbara region (Churchill 2008; Australasian Bat Society, Inc[1]). While I have not seen the bat detector recording associated with a past record of detection, I suggest that this identification is more likely the result of an over-enthusiastic attribution.

Further details are available should verification be required.

[1] https://www.ausbats.org.au/batmap.html

Methods

The data provided were recorded in full spectrum WAV format with Titley Scientific Anabat Swift bat detectors (sampling rate 500 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong et al. 2021a,b) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language application that performed three tasks:

1. undertook a Discriminant Function Analysis on training datasets from representative echolocation calls of Pilbara cave-roosting bat species, the Pilbara Leaf-nosed Bat and other northern Australian bat species;

2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over ellipses representing one standard deviation of the variation for the defined call types; and

3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition version 22.

Species were identified based on information in Armstrong and Coles (2007) and the author's own unpublished material. The occurrence of the Northern Leaf-nosed Bat was checked against distribution information in Churchill (2008) and the BatMap resource hosted by the Australasian Bat Society, Inc[2].

[2] https://www.ausbats.org.au/batmap.html

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of three target bat species in bulk ultrasonic recordings. Further comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was set up and supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information of the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. While Specialised Zoological has made identifications to the best of our ability given the available materials, and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.
9. The most reliable way of detecting the Ghost Bat with bat detectors is to place the equipment with the microphone facing into a potential cave roosting site. The echolocation calls of this species are of low amplitude, and therefore most detectable when a Ghost Bat flies close to the bat detector as it exits the underground structure. If there is uncertainty about whether Ghost Bats are present in a cave, then video recordings can be a useful addition to the survey. The detection of Ghost Bats with bat detectors away from cave entrances is less reliable.

References

Armstrong, K.N. and Coles, R.B. (2007). Echolocation call frequency differences between geographic isolates of *Rhinonicteris aurantia* (Chiroptera: Hipposideridae): implications of nasal chamber size. *Journal of Mammalogy* 88: 94–104. http://dx.doi.org/10.1644/06-MAMM-A-115R1.1

Armstrong K.N., Broken-Brow J., Hoye G., Ford G., Thomas M. and Corben C. (2021a). Effective detection and identification of sheath-tailed bats of Australian forests and woodlands. *Australian Journal of Zoology* 68: 346–363. https://doi.org/10.1071/ZO20044

Armstrong K.N., Clarke S., Linke A., Scanlon A., Roetman P., Hitch, A.T. and Donnellan S.C. (2021b). Citizen science implements the first intensive acoustics-based survey of insectivorous bat species across the Murray-Darling Basin of South Australia. *Australian Journal of Zoology* 68: 364–381. https://doi.org/10.1071/ZO20051

Churchill, S.K. (2008). *Australian bats.* 2nd ed. Allen and Unwin, Crows Nest, NSW.

Specialised Zoological (2022). Acoustic analysis and bat call identification from Lynas Find, Western Australia. Unpublished report by Specialised Zoological for Animal Plant Mineral Pty Ltd, 20 October 2022, project reference SZ627.

Table 1. Summary of bat detector recordings analysed.

Serial	Night	Coordinates
622904	4/10/2022	21.040270 S, 118.884913 E
622904	5/10/2022	21.040285 S, 118.885012 E, 159 m
622904	6/10/2022	21.040412 S, 118.884940 E, 160 m
622904	7/10/2022	21.040223 S, 118.885180 E, 211 m
622904	8/10/2022	21.040365 S, 118.885098 E, 190 m
622904	9/10/2022	21.040332 S, 118.884955 E, 178 m
622904	10/10/2022	21.040448 S, 118.885117 E, 168 m
622904	11/10/2022	21.040368 S, 118.885002 E, 184 m
622904	12/10/2022	21.040173 S, 118.885027 E, 168 m
622904	13/10/2022	21.040375 S, 118.884973 E, 176 m
622904	14/10/2022	21.040203 S, 118.885565 E, 185 m
622904	15/10/2022	21.040393 S, 118.884940 E, 165 m
622904	16/10/2022	21.040393 S, 118.884893 E, 161 m
622904	17/10/2022	21.040288 S, 118.884968 E, 124 m
622904	18/10/2022	21.040425 S, 118.884837 E, 151 m
622904	19/10/2022	21.040382 S, 118.884923 E, 159 m
642029	5/10/2022	21.075802 S, 118.882870 E
642029	6/10/2022	21.075845 S, 118.882947 E, 170 m
642029	7/10/2022	21.075825 S, 118.882932 E, 184 m
642029	8/10/2022	21.075828 S, 118.882923 E, 180 m
642029	9/10/2022	21.075425 S, 118.883522 E, 334 m
642029	10/10/2022	21.075822 S, 118.882870 E, 210 m
642029	11/10/2022	21.075272 S, 118.882767 E, 242 m
642029	12/10/2022	21.075763 S, 118.882850 E, 170 m
642029	13/10/2022	21.075893 S, 118.882923 E, 185 m
642029	14/10/2022	21.074850 S, 118.883212 E, 164 m
642029	15/10/2022	21.075717 S, 118.882853 E, 173 m
660630	4/10/2022	21.074392 S, 118.875240 E, 161 m
660630	5/10/2022	21.074278 S, 118.875868 E, 224 m
660630	6/10/2022	21.074415 S, 118.875243 E, 171 m
660630	7/10/2022	21.074437 S, 118.875250 E, 169 m
660630	8/10/2022	21.074425 S, 118.875265 E, 175 m
660630	9/10/2022	21.074418 S, 118.875267 E, 166 m
660630	10/10/2022	21.074453 S, 118.875292 E, 168 m
660630	11/10/2022	21.074402 S, 118.875257 E, 173 m
660630	12/10/2022	21.074398 S, 118.875240 E, 179 m
660630	13/10/2022	21.074430 S, 118.875240 E, 179 m
660630	14/10/2022	21.074257 S, 118.875652 E, 197 m
660630	15/10/2022	21.074362 S, 118.875233 E, 174 m
660630	16/10/2022	21.074502 S, 118.875272 E, 186 m
660630	17/10/2022	21.074332 S, 118.875245 E, 167 m
660630	18/10/2022	21.074427 S, 118.875240 E, 175 m
660630	19/10/2022	21.074445 S, 118.875340 E, 188 m
660630	20/10/2022	21.074282 S, 118.875203 E, 164 m

Serial	Night	Coordinates
660654	5/10/2022	21.041485 S, 118.899255 E
660654	6/10/2022	21.044085 S, 118.895025 E, 184 m
660654	7/10/2022	21.044080 S, 118.894970 E, 172 m
660654	8/10/2022	21.044070 S, 118.894972 E, 172 m
660654	9/10/2022	21.044035 S, 118.894972 E, 187 m
660654	10/10/2022	21.044042 S, 118.894988 E, 174 m
660654	11/10/2022	21.044078 S, 118.894970 E, 191 m
660654	12/10/2022	21.044085 S, 118.894963 E, 188 m
660654	13/10/2022	21.044030 S, 118.894960 E, 176 m
660654	14/10/2022	21.044083 S, 118.894997 E, 183 m
660654	15/10/2022	21.043912 S, 118.895568 E, 200 m
660654	16/10/2022	21.044023 S, 118.894975 E, 189 m
660654	17/10/2022	21.044023 S, 118.894962 E, 175 m
660654	18/10/2022	21.044028 S, 118.894957 E, 171 m
660654	19/10/2022	21.044025 S, 118.894975 E, 177 m

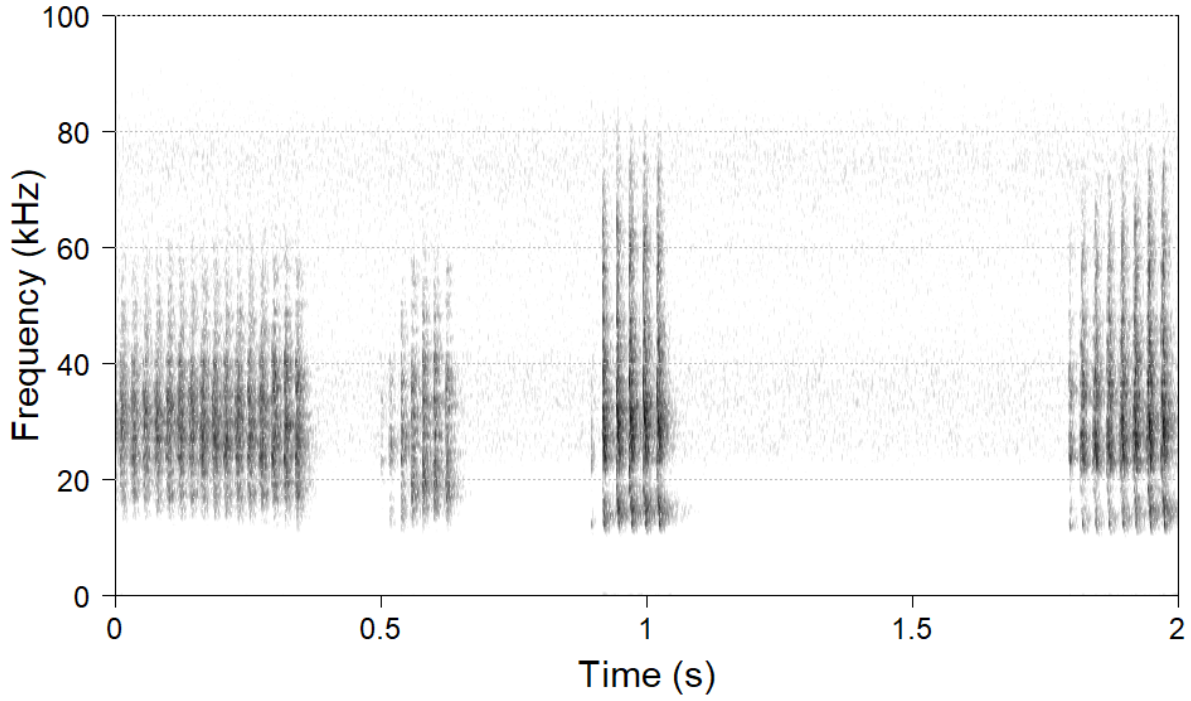


Figure 1. Example of an insect with a call stridulation pattern that has some similarity to the structure of echolocation calls of the Ghost Bat.

APPENDIX F: SPECIES BY SITE MATRIX - FLORA

Species	Status	P2Q1	P2Q2	P2Q3	P2Q4	P2Q5	P2Q6	P2R1	P2R2	P2R3	P2R4	P5Q1	P5Q2	P5Q3	P5Q4	P5Q5	P5Q6	P5R1	P5R2	P5R3	P5R4	P5R5
Amaranthaceae																						
Aerva javanaica	*Int.*				1										0.1			1				
Alternanthera nodiflora															0.1							
Ptilotus aervoides														0.1								
Ptilotus astrolasis		0.1		0.1		0.1	0.1	0.1	0.1			0.1	0.1		0.1	0.1	0.5				0.1	
Ptilotus auriculifolius									0.1				0.1		0.1							
Ptilotus axillaris						0.1	0.1		0.1		0.1											
Ptilotus calostachyus		0.5	0.1	0.1		0.1	1		0.1			0.1	0.1		0.1	0.1	1				0.1	
Ptilotus clementii			0.1			0.1															0.1	
Ptilotus exaltatus																					0.1	
Ptilotus helipteroides									0.1				0.1			0.2					0.1	
Asteraceae																						
Flaveria trinervia	*Int.*									0.1		0.1	0.1									
Pluchea rubelliflora										0.1												
Pluchea tetranthera					0.1																	0.1
Pterocaulon sphacelatum															0.2							
Streptoglossa ?decurrens															0.1			0.1				
Streptoglossa odora													0.1							2		
Boraginaceae																						
Euploca chrysocarpa			0.5	0.1																		
Euploca ovalifolia						0.1																
Chenopodiaceae																						
Dysphania rhadinostachya						0.1	0.1						0.1									
Cleomaceae																						
Arivela uncifera						0.1	0.1	0.1									0.1				0.1	
Convolvulaceae																						
Bonamia ?rosea					0.1								0.1			0.1			0.1	0.1		0.1
Bonamia erecta				0.5	0.1	0.1	1	0.1	0.5	0.1	0.1	0.1		0.1		0.1	0.1	0.1	0.1		0.1	
Bonamia media						0.1	0.1															
Bonamia pilbarensis																						
Bonamia rosea																						
Polymeria ambigua															0.1							

Species	Status	P2Q1	P2Q2	P2Q3	P2Q4	P2Q5	P2Q6	P2R1	P2R2	P2R3	P2R4	P5Q1	P5Q2	P5Q3	P5Q4	P5Q5	P5Q6	P5R1	P5R2	P5R3	P5R4	P5R5
Cucurbitaceae																						
Cucumis argenteus												0.1										
Cucumis variabilis					0.1																	
Cyperaceae																						
Cyperus bifax								0.1														
Euphorbiaceae																						
Euphorbia careyi															0.1							
Euphorbia coghlanii																				0.1		
Euphorbia mitchelliana					0.1								0.1		0.1							
Fabaceae																						
Acacia adsurgens		2		1		0.1			2	2		5	2	2	1	5	0.5		0.5		0.5	
Acacia bivenosa			0.5					2		2	0.5	1	2	0.1					0.5			0.5
Acacia inaequilatera		1		1	0.5	0.5	0.5	0.1	0.1						0.5	0.5		0.1			0.5	0.5
Acacia orthocarpa			0.5																			
Acacia stellaticeps			1		2			0.5		5	0.5											
Acacia synchronicia													0.6									
Acacia trachycarpa																						0.5
Acacia tumida		0.1	1	15	5	10	0.5	2	5	5	1				2	2	5	2			5	0.5
Cajanus cinereus					0.5						0.5				0.1			1	0.1			0.5
Crotalaria cunninghamii					0.5			0.5														
Crotalaria medicaginea				0.1											1							
Cullen leucanthum					0.1																	
Cullen stipulaceum					0.1																	0.1
Indigofera hirsuta		0.1																				
Indigofera monophylla		0.1	0.1	0.1			0.1	0.1	0.1			0.1	0.1	0.1	0.5	1	1	0.5	0.5	0.1	0.1	0.5
Indigofera rugosa			0.1			0.1					0.1											
Neptunia dimorphantha													0.1									
Neptunia monosperma														0.2								
Petalostylis labicheoides												0.5	1		0.5			0.2	0.5		0.5	
Rhynchosia minima								0.1		0.1	0.1		0.1					0.1	0.1			0.1
Senna artemisioides subsp. *helmsii*			0.1																			
Senna artemisioides subsp. *oligophylla*					0.1					0.1												

Species	Status	P2Q1	P2Q2	P2Q3	P2Q4	P2Q5	P2Q6	P2R1	P2R2	P2R3	P2R4	P5Q1	P5Q2	P5Q3	P5Q4	P5Q5	P5Q6	P5R1	P5R2	P5R3	P5R4	P5R5
Senna ferraria												0.1	0.1							0.1		
Senna glutinosa																						
Senna glutinosa subsp. *glutinosa*																		0.1				
Senna notabilis						0.1			0.5				0.1		0.1					0.1		0.1
Tephrosia arenicola				0.1	0.5	1	0.2	0.1	0.5													
Tephrosia clementii							0.1					0.1					0.1					
Tephrosia rosea					0.1				0.1						0.1			0.1	0.1			
Goodeniaceae																						
Goodenia lamprosperma								0.1	0.1		0.1	0.1	0.1	2	0.1	0.1	0.1	0.1		2	0.1	0.1
Goodenia microptera						0.1	0.1		0.1													
Goodenia muelleriana																			0.1			
Goodenia scaevolina		1		1			0.2		0.5								0.1				0.1	0.1
Scaevola amblyanthera			0.1	0.1						0.1	0.1				0.1	0.1			0.1			
Haloragaceae																						
Gonocarpus ephemerus			0.1																			
Haloragis maierae			0.1																			
Lauraceae																						
Cassytha filiformis			0.1	1	0.5					0.1	0.5	0.1						0.1				
Malvaceae																						
Abutilon lepidum																		0.2				0.1
Corchorus incanus		1	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.1	1	1	0.1	0.5	0.1	0.1	1	0.1	0.1	0.1	0.1
Gossypium australe								0.5			0.5				0.1							0.1
Gossypium sturtianum					0.1																	
Hibiscus burtonii																						0.1
Hibiscus leptocladus						0.1																
Malvastrum americanum	*Int.*																					0.1
Melhania oblongefolia											0.1		0.1									0.1
Nellica maderaspatensis											0.1								0.1			
Sida arenicola			0.2		0.5			0.1			0.1				0.1	0.1						
Sida fibulifera													0.1									
Sida rohlenae																				0.1		
Triumfetta pentandra	*Int.*														0.2			0.1				0.1

Species	Status	P2Q1	P2Q2	P2Q3	P2Q4	P2Q5	P2Q6	P2R1	P2R2	P2R3	P2R4	P5Q1	P5Q2	P5Q3	P5Q4	P5Q5	P5Q6	P5R1	P5R2	P5R3	P5R4	P5R5
Molluginaceae																						
Trigastrotheca molluginea		0.1		0.1		0.1	0.5		0.1	0.1		0.1		0.1		0.1	0.1	0.1			0.1	
Myrtaceae																						
Corymbia hamersleyana		2	2		2	0.1		1.5		0.5					1			10	2	2		5
Eucalyptus camaldulensis					5			5			10				4							
Eucalyptus victrix										1												
Nyctaginaceae																						
Boerhavia gardneri						0.1																
Phyllanthaceae																						
Notoleptopus decaisnei													0.1									
Poaceae																						
?Sorghum plumosum											0.5											
Aristida holathera											0.1											
Cenchrus ciliaris	*Int.*				10			15		15	5				2			5	5	0.1		10
Cenchrus setiger	*Int.*				5			5		2					10			5	5			15
Chrysopogon fallax				0.1	0.1						0.5				0.2				2			0.1
Cymbopogon obtectus					0.1			0.1		0.1	0.1											
Dichanthium sericeum																			2			
Enneapogon lindleyanus													0.1					0.5				
Eragrostis eriopoda			0.5			0.5			0.5													
Eriachne mucronata						1							0.5	2	0.5							
Eriachne pulchella																				0.1		
Eulalia aurea															0.5							
Heteropogon contortus								0.1						2	0.5							
Paraneurachne muelleri			0.1								0.1											
Themeda avenacea								0.1										0.5	2			
Themeda triandra					1			0.1			0.5				0.5			0.5	2	0.1		0.1
Triodia angusta												60	30	15		25	10		20			
Triodia brizoides				5			5							40		5						
Triodia epactia		5	2	10	15	5		10	20	10	10	10	5	5	3	15		5	15	0.1	5	5
Triodia lanigera		5	35	25	10	1	15		5	5			5		2	2		5				10
Triodia wiseana		35	10			10											30				40	

Species	Status	P2Q1	P2Q2	P2Q3	P2Q4	P2Q5	P2Q6	P2R1	P2R2	P2R3	P2R4	P5Q1	P5Q2	P5Q3	P5Q4	P5Q5	P5Q6	P5R1	P5R2	P5R3	P5R4	P5R5
Portulacaceae																						
Portulaca oleracea	mixed														0.1							
Proteaceae																						
Grevillea pyramidis																		0.1				
Grevillea wickhamii		1		1		0.1		0.1	0.1							1	0.5					
Hakea loreus											0.1					0.1			0.1			0.1
Santalaceae																						
Santalum lanceolatum					1																	
Dodonaea coriacea						0.1																
Scrophulariaceae																						
Eremophila forrestii subsp. *forrestii*		0.1																				
Solanaceae																						
Solanum ?horridum																0.1						
Solanum diversiflorum													0.1							0.5		
Solanum phlomoides															0.1					0.1		
Typhaceae																						
Typha domingensis										1												
Violaceae																						
Afrohybanthus aurantiacus				0.1		0.1										0.1		0.1	0.1			
Zygophyllaceae																						
Tribulus hirsutus							0.1						0.1									
Not previously recorded for the Pilgangoora project																						
Int: Introduced species. Mixed: native to part of the range, introduced to part of the range.																						

APPENDIX G: FAUNA LIKELIHOOD OF OCCURRENCE ASSESSMENT - FAUNA

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
-- Birds --					
Actitis hypoleucos	Common Sandpiper	MI	MI	Edge of sheltered waters salt or fresh (*e.g.* estuaries, mangrove creeks, rocky coasts, near-coastal saltlakes (including saltwork ponds), river pools, lagoons, claypans, drying swamps, flood waters, dams and sewage ponds. Preferring situations where low perches are available (Johnstone and Storr, 1998). Shallow, pebbly, muddy or sandy edges of rivers and streams coastal to far inland; dams, lakes, sewage ponds; margins of tidal rivers, waterways in mangroves or saltmarshes; mudflats: rocky or sand beaches; causeways, riverside lawns, drains, street gutters. (Pizzey and Knight, 2012).	Possible. The gilgai areas provide inundated clay soils suitable for waders, however these areas do not provide perching opportunities. Perching opportunities available in the creeks however limited water pooling was observed. Two records 20 km to the west from a semi-permanent pool in a tributary of the Turner River. No Nationally or Internationally Important Congregations occur.
Apus pacificus	Fork-tailed Swift	MI	MI	Broadly distributed aerial species that is not specifically limited to any particular habitat type. Aerial: over open country, from semi-arid deserts to coasts, islands; sometimes over forests, cities. (Pizzey and Knight, 2012). Occurs over dry or open habitats comprising of riparian woodland, low scrub, heathland, or saltmarsh, also grasslands and sandplains with spinifex. (Morcombe, 2011).	Possible. No local records but listed by the PMST as Likely to occur. Seven records are reported from 1998 – 2014 over a wide variety of habitats. This species is distributed across Australia. It is an aerial species that rarely comes to land. Individuals would not be specifically dependant on any habitats present in the Study Area.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
Calidris acuminata	Sharp-tailed Sandpiper	MI	MI	Scarce to moderately common (much more plentiful near coasts than in interior). (Johnstone and Storr, 1998). Tidal mudflats, saltmarshes, mangroves; shallow fresh, brackish or saline inland wetlands; floodwaters, irrigated pastures and crops; sewage ponds, saltfields. Widespread summer migrant to coastal and inland Australia. (Pizzey and Knight, 2012).	Possible. The gilgai areas provide seasonally inundated clay soils. Limited pooling of water in the ephemeral drainage lines. No Permanent pools. No records in the local area. PMST considers the species May occur.
Calidris ferruginea	Curlew Sandpiper	CR	CR, MI	Mainly shallows of estuaries and near-coastal saltlakes (including saltwork ponds) and drying near-coastal freshwater lakes and swamps. Also beaches and near-coastal sewage ponds. (Johnstone and Storr, 1998) Tidal mudflats; saltmarsh, saltfields; fresh, brackish or saline wetlands; sewage ponds. (Pizzey and Knight, 2012)	Possible. The gilgai areas provide seasonally inundated clay soils. Limited pooling of water in the ephemeral drainage lines. No Permanent pools. No records in the local area. PMST considers the species May occur.
Calidris melanotos	Pectoral Sandpiper		MI	Mainly fresh waters (swamps, lagoons, river pools, irrigation channels and sewage ponds); also, samphire flats around estuaries and saltlakes. (Johnstone and Storr, 1998) Shallow fresh waters, often with low grass or other herbage; swamp margins, flooded pastures, sewage ponds, occasionally tidal areas, saltmarshes. (Pizzey and Knight, 2012)	Possible. The gilgai areas provide seasonally inundated clay soils. Limited pooling of water in the ephemeral drainage lines. No Permanent pools. No records in the local area. PMST considers the species May occur.
Charadrius veredus	Oriental Plover	MI	MI	Open plains; bare, rolling country, often far from water; ploughed land; muddy or sandy wastes near inland swamps or tidal mudflats; bare claypans; margins of	Likely. The gilgai areas provide inundated clay soils suitable for Oriental Plover. There is a 1999 record 250 m from Option 2. This area is now part of the active

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
				coastal marshes; grassy fields and lawns. (Pizzey and Knight, 2012).	Pilgangoora operations. Prior to clearing it would have been similar habitat to the gilgai areas.
Erythrotriorchis radiatus	Red Goshawk	VU	VU	Well-wooded country. (Johnstone and Storr, 1998) Open forests, woodlands, especially near rivers, wetlands; rainforest fringes. (Pizzy and Knight, 2012)	Unlikley. No records are known from the Pilbara and not within the range of the species known distribution (BirdLife International 2022, TSSC 2015).
Falco hypoleucos	Grey Falcon	VU	VU	Mainly lightly wooded and coastal riverine flats. (Johnstone and Storr, 1998) Lightly treed and inland plains; gibber deserts, sandridges, pastoral lands, timbered watercourses; seldom in driest deserts (Pizzey and Knight, 2012).	Likely. The Study Areas are potentially suitable foraging habitat. Listed by EPBC as Known to Occur in the search radius and five records since 2012 near the Turner River and larger tributaries. The closest record is 10 km south west of the Study Area. All habitats in the Study Areas are suitable foraging habitat for this species. The red gum is unsuitable for nesting due to the low stature.
Falco peregrinus	Peregrine Falcon	OS	-	Mainly about cliffs along coasts, rivers and ranges, and about wooded watercourses and lakes (Johnstone and Storr, 1998). Cliffs, gorges, timbered watercourses, environs of rivers, wetlands, plains, open woodlands, pylons, spires, buildings. (Pizzey and Knight, 2012)	Likely. All habitats are suitable. One record from 2002 is 250 m from the Study Area. This location is now the site of the Pilgangoora mine.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
Glareola maldivarum	Oriental pratincole	MI	MI	Feeding in air and roosting on bare ground beside water, *e.g.* tidal flats and floodwaters (Johnstone and Storr, 1998). Plains; shallow wet and dry edges of open bare wetlands; tidal mudflats, beaches (Pizzey and Knight, 2012).	Possible. The gilgai areas provide seasonally inundated clay soils. Limited pooling of water in the ephemeral drainage lines. No Permanent pools. No records in the local area. PMST considers the species May occur.
Hirundo rustica	Barn swallow	MI	MI	Mainly towns and wetlands (sewage and saltworks ponds, river pools, swamps, tidal creeks and reservoirs). (Johnstone and Storr, 2004) Open country; agricultural land, especially near water; railyards, towns, overhead wires. (Pizzey and Knight, 2012)	Possible. The gilgai areas provide seasonally inundated clay soils. Limited pooling of water in the ephemeral drainage lines. No Permanent pools. No records in the local area. PMST considers the species May occur.
Motacilla cinerea	Grey Wagtail	MI	MI	Mainly banks and rocks in fast-running fresh water habitats; rivers, creeks, streams and around waterfalls, both in forest and open country; but occurs almost anywhere during migration. Flits from rock to rock, and often enters water after insects (or performs flycatcher sallies after them). (Johnstone and Storr, 2004) In Australia, near running water in disused quarries; sandy, rocky streams in escarpments and rainforests; sewage ponds, ploughed fields, airfields. (Pizzey and Knight, 2012)	Unlikely. The drainage lines in the Study Area are highly ephemeral and would only flow for brief period of time. Drainage lines are in plains habitat where fast running channel flow is limited. There are no previous records in the local area and the species is uncommonly recorded in Australia. No records in the local area. PMST considers the species May occur.
Motacilla flava	Yellow Wagtail	MI	MI	Damp short-grass flats: rice stubbles and edge of swamps, sewage ponds, bore overflows, grazed or	Possible. Suitable habitat occurs in the gilgai during seasonal inundation.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
				mowed grass and irrigated areas. (Johnstone and Storr, 2004)	No records in the local area. PMST considers the species Likely to occur.
Numenius madagascariensis	Eastern Curlew	CR	CR, MI	Mainly tidal mudflats; also reef flats, sandy beaches and rarely near-coastal lakes (including saltwork ponds). (Johnstone and Storr, 1998) Estuaries, tidal mudflats, sandspits, saltmarshes, mangroves; occasionally fresh or brackish lakes; bare grasslands near water. (Pizzey and Knight, 2012)	Possible, but prefers saline habitats.
Pezoporus occidentalis	Night Parrot	CR	EN	Treeless or sparsely wooded spinifex *Triodia* spp. near water (including artesian bores) (Johnstone and Storr, 1998). Seeding spinifex on stony rises, breakaway country, sandy lowlands; shrubby glasswort, chenopods; succulents on flats around salt lakes; flooded claypans saltbush, bluebush, bassia associations (Pizzey and Knight, 2012).	Possible. No local records. Habitat modelling includes the Study Area at the extremity of the species potential extent. Foraging resources are limited.
Rostratula australis	Australian Painted-Snipe	EN	EN	Common in south and north-east Kimberley swampy plains before their degradation by cattle, but only five records since 1909. Rare summer visitor to North-west, single birds recorded at man-made ponds in the Hamersley and Ophthalmia Ranges in December and January and a male collected at Carnarvon in November. In arid interior a female about to lay collected at	Unlikely. No habitat occurs in the Study Area. Vegetation too open to provide well vegetated shallows. No records in the local area. PMST considers the species May occur.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
				Brockman Creek in August 1896 (Johnstone and Storr, 1998). Well-vegetated shallows and margins of wetlands, dams, sewage ponds; wet pastures, marshy areas, irrigation systems, lignum, tea-tree scrub, open timber. (Pizzey and Knight, 2012)	
				-- Mammals --	
Dasycercus blythi	Brush-tailed Mulgara	P4	-	Inhabits spinifex grasslands and burrows on the flats between low sand dunes (Van Dyck and Strahan, 2008).	Possible. Sandy rises in the undulating plains habitat is suitable.
Dasyurus hallucatus	Northern Quoll	EN	EN	The Northern Quoll will usually den in hollow tree trunks (Hill and Ward, 2010) or in small caves and crevices in rocky outcrops.	Likely. Foraging habitat available in the creek lines, however is likely to be poor quality as lacking in litter and vegetation cover due to heavy grazing. Trees too small to provide hollows suitable for denning. Confirmed to occur in the rocky range 4 km to the east. One record 1.2 km to the northeast of Option 2.
Hipposideros stenotis	Northern Leaf-nosed Bat	P2		It is found near the entrance of shallow caves and abandoned mines where they are usually very sensitive to the approach of an observer (Duncan *et al*. 1999). It forages in forest, woodlands and grasslands in close proximity to rocky outcrops and escarpments (Churchill 2008).	Unlikely. Very few records in the Pilbara. Database records from 2012 are a cluster of acoustic recordings, however the location is stated as 'Great Sandy Desert' therefore have low spatial accuracy. The accepted distribution of this species does not include in the Pilbara region (*e.g.*, Churchill 2008). Records may be a result of misidentification of echolocation records (Appendix E).

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
Lagorchestes conspicillatus leichardti	Spectacled Hare-Wallaby	P4	-	Open *Acacia* forests, open woodlands and tall shrubland over tussock or hummock grasslands (Van Dyck and Strahan, 2008).	Unlikely. Historic records nearby however habitat is too open to be suitable.
Macroderma gigas	Ghost Bat	VU	VU	Their distribution is influenced by the availability of suitable caves and mines for roost sites (Churchill 2008). In the Pilbara, ghost bats prefer to forage on productive plain areas with thin mature woodland over patchy or clumped tussock or hummock grass (Triodia spp.) on sand or stony ground (Bat Call WA 2021a).	Likely. Foraging habitat available across the Study Area. No roosting habitat available. Study Areas within foraging range of database record locations.
Macrotis lagotis	Bilby	VU	VU	Occupy a variety of inland habitats including grass and stony downs country on cracking clays, desert sandplains and dune fields of laterite with hummock grassland and massive red earths with *Acacia* shrubland (Van Dyck and Strahan, 2008).	Possible. Suitable habitat includes the undulating plains habitats. Historic record nearby, recent records 16 km to the west.
Pseudomys chapmani	Western Pebble-mound Mouse	P4	-	Found on stony hillsides with hummock grassland (Menkhorst and Knight, 2009)	Present. Mounds located in the stony rises of the undulating plains habitats. .
Rhinonicteris aurantia	Pilbara Leaf-Nosed Bat	VU	VU	Dependant on deep and complex cave systems. Roosting and foraging habitats defined by TSSC (2016) and Bat Call WA (2021b)	Likely. No roosting habitat available, foraging quality of habitats in the Study Area is Low. Not recorded in acoustic survey. May fly over the area to reach more productive foraging habitat.
Sminthopsis longicaudata	Long-tailed Dunnart	P4		A specialist rock dwelling species (Freeland *et al.* 1988). It prefers exposed rock and stony soils with hummock	Unlikely. No suitable habitat.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
				grasses and shrubs, on flat-topped hills, lateritic plateaus, sandstone ranges and breakaways.	
				-- Reptiles --	
Anilios ganei	Gane's blind snake (Pilbara)	P1		Known from widely separated areas between Newman and Pannawonica. Possibly associated with moist gorges and gullies (Wilson and Swan 2008).	Unlikely. Suitable habitat unlikely to be present as drainage lines small and highly ephemeral. No termite mounds present for foraging resource.
Liasis olivaceus subsp. *baronni*	Pilbara Olive Python	VU	VU	Recorded in areas with gorges and escarpments in close proximity to water holes (Doughty *et al*. 2011). During the cooler months they will typically hide in caves, crevices and fissures away from water sources. However, in the warmer months they become active and tend to stay near rocky outcrops and water.	Unlikely. No suitable habitat. There are no gorges or significant water filled gullies in the Study Area. No permanent or semi-permanent pools in the creeks. No caves, crevices or fissures.
Liopholis kintorei	Great Desert Skink		VU	A nocturnal burrowing and social lizard, living in family groups and creating extensive burrows that are typically 1 m deep and up to 10 m in diameter with multiple entrances (McAplin 2001). Typically occupy hummock grass sandplains and some adjacent dunefield swales, though they can occur in a variety of habitats (McAplin 2001). Vegetation usually consists of hummock grassland (*Triodia basedowii*, *T. pungens* and *T. schinzii*), with some scattered shrubs and occasional trees (*e.g*. Acacia spp., Eucalyptus spp., Hakea spp., Grevillea spp. and Allocasuarina decaisneana) (McAlpin 2001). Tend to utilise areas of habitat that have	Unlikely. No records in the local area. PMST considers the species May occur. The area where suitable habitat may occur is 10 km to the east of the Study Area and separated by a rocky range.

Species	Common Name	Conservation Code		Relevant Habitat Preference	Assessment of Occurrence
		BC Act	EPBC Act		
				been burnt within the previous 2-15 years (McAplin 2001; Morre *et al*. 2015).	

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APPENDIX 4 – SITE ENVIRONMENTAL RISK ASSESSMENT PROCESS

The Site Environmental Risk Assessment was undertaken to identify the high-level environmental risks for the construction, operation and closure phases for the Project. The primary objectives of the risk assessment process were to identify major environmental risks to ensure:

- Prioritisation of risk management activities
- Adequate control measures are in place to manage the identified major risks
- Identification of risks that require additional control measures
- Development of an Environmental Obligations Register
- Understanding amongst key operational staff of the environmental risks associated with the project.

Each identified risk or potential impact was analysed for likelihood and consequence and a risk ranking assigned. The levels for likelihood and consequence used are detailed in Table 1 and Table 2.

The risk matrix (Table 3) combines the level of likelihood and consequence to determine the level of associated risk. The risk rating (or environmental impact) for each risk was categorised as extreme (red), high (orange), medium (yellow) or low (green).

For each risk, an assessment was made of the associated risk rating assuming no operational controls or treatments were in place. This provided the inherent risk for the hazard. The risk rating for each risk or potential impact was then re-assessed assuming the proposed operational controls were in place to provide a residual risk rating. The risk assessment is included as Table 10.

Table 1: Likelihood definitions

LIKELIHOOD	#	DESCRIPTION
Almost Certain	1	The event is a common or frequent occurrence or an ongoing impact (e.g. daily).
Likely	2	The event is expected to occur under some conditions, or has occurred more than once.
Possible	3	The event will probably occur, or has occurred under some conditions (e.g. yearly).
Unlikely	4	Known to have occurred but not often.
Rare	5	Very unlikely/may occur in exceptional circumstances.

Table 2: Consequence definitions

CONSEQUENCE	#	DESCRIPTION
Insignificant	A	Confined to the immediate area, rapid clean up, no environmental damage.
Minor	B	Confined to an isolated area, rapid clean up using internal resources, minimal environmental damage, vegetation recovery within 1-2 years.
Moderate	C	Impact confined to the mine, clean up may require external assistance, moderate environmental damage, vegetation recovery within 2-5 years, regulatory report required.
Major	D	Major environmental impact, extends beyond mine, considerable clean up using internal and external resources, vegetation recovery takes 5+ years, potential for prosecution and adverse publicity.
Catastrophic	E	Severe environmental impact, extensive clean up and recovery period, requires ongoing internal and external resources, vegetation may not recover, prosecution.

Table 3: Environmental Risk Matrix

RISK MATRIX		CONSEQUENCE				
		Insignificant (A)	**Minor (B)**	**Moderate (C)**	**Major (D)**	**Catastrophic (E)**
Likelihood	**Almost Certain (1)**	Moderate	High	Critical	Critical	Critical
	Likely (2)	Moderate	Moderate	High	Critical	Critical
	Possible (3)	Low	Moderate	Moderate	High	High
	Unlikely (4)	Low	Low	Moderate	Moderate	High
	Rare (5)	Low	Low	Low	Moderate	Moderate