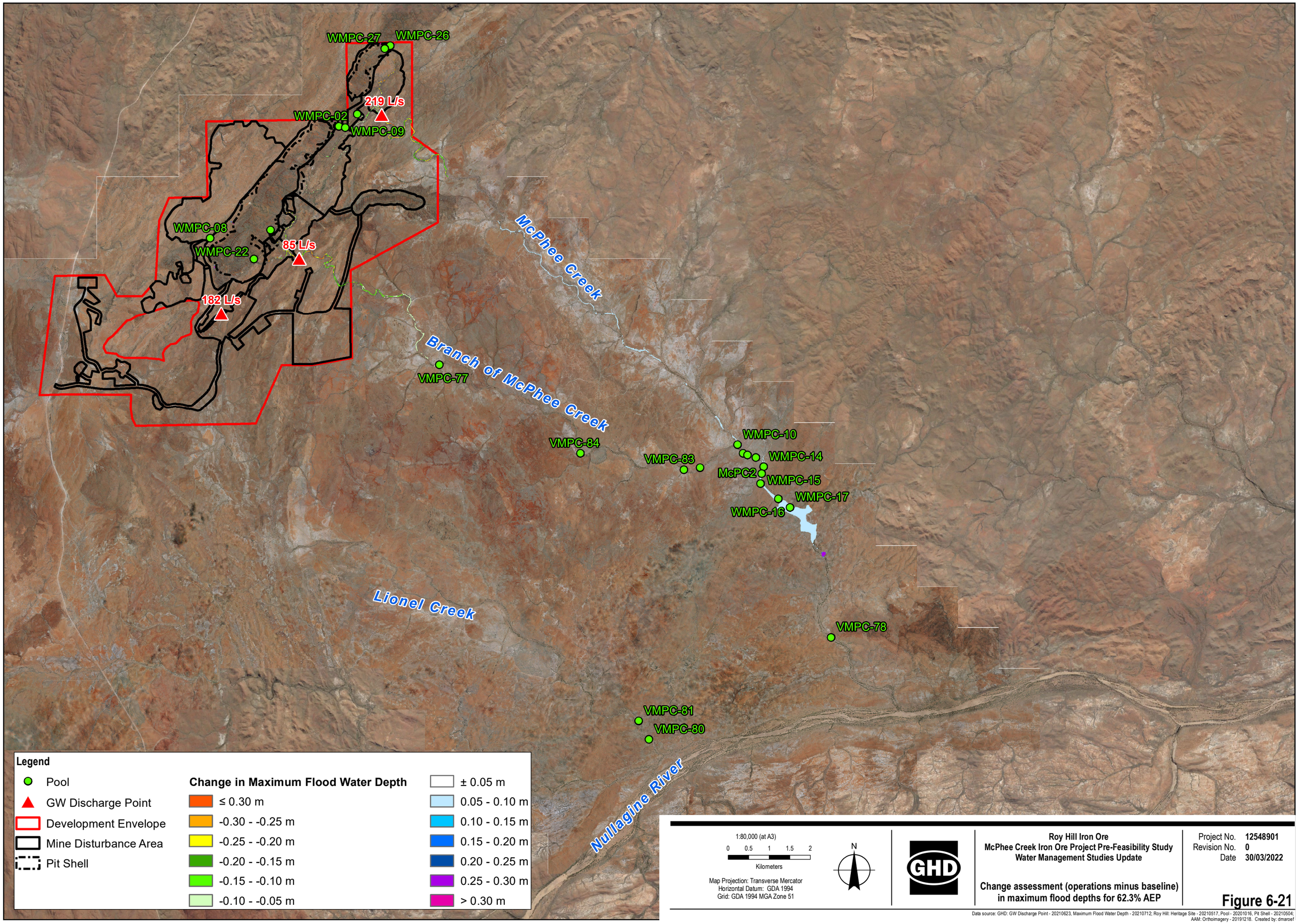
WMPC-27
WMPC-26
219 L/s
WMPC-02
WMPC-09
WMPC-08
WMPC-22
85 L/s
182 L/s
McPhee Creek
Branch of McPhee Creek
VMPC-77
VMPC-84
VMPC-83
WMPC-10
WMPC-14
McPC2
WMPC-15
WMPC-17
WMPC-16
Lionel Creek
VMPC-78
VMPC-81
VMPC-80
Nullagine River
Legend
Pool
GW Discharge Point
Development Envelope
Mine Disturbance Area
Pit Shell
Change in Maximum Flood Water Depth
≤ 0.30 m
-0.30 - -0.25 m
-0.25 - -0.20 m
-0.20 - -0.15 m
-0.15 - -0.10 m
-0.10 - -0.05 m
± 0.05 m
0.05 - 0.10 m
0.10 - 0.15 m
0.15 - 0.20 m
0.20 - 0.25 m
0.25 - 0.30 m
> 0.30 m
1:80,000 (at A3)
0 0.5 1 1.5 2
Kilometers
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51
N
GHD
Roy Hill Iron Ore
McPhee Creek Iron Ore Project Pre-Feasibility Study
Water Management Studies Update
Change assessment (operations minus baseline)
in maximum flood depths for 62.3% AEP
Project No. 12548901
Revision No. 0
Date 30/03/2022
Figure 6-21
Data source: GHD: GW Discharge Point - 20210623, Maximum Flood Water Depth - 20210712; Roy Hill: Heritage Site - 20210517, Pool - 20201016, Pit Shell - 20210504;
AAM: Orthoimagery - 20191218. Created by: dmaroef

6.5.2 Indirect impacts

Implementation of the Proposal has the potential to result in a reduction in quality of groundwater and surface water as a result of:

- post closure formation of permanent or ephemeral pit lakes
- surface water discharge
- alteration of surface water quality from mine runoff including:
  - waste dumps and waste fines storage
  - increased sediments from infrastructure and drainage
  - storage and handling of hazardous materials, hydrocarbons and waste.

6.5.2.1 Post closure formation of permanent or ephemeral pit lakes

Permanent pit lakes are expected to form at closure in the Avon and Murray pits, with marginal lakes in parts of the Ord pit. The Nicholson Pit is predicted to remain essentially dry, except after major rainfall events. The recovery modelling shows that the pit lakes are expected to remain long-term evaporative sinks with steady state lake levels well below the existing ground levels. While some flow through Nicholson and Ord Pit to Murray and Avon Pit is expected, the pit lake system as a whole is expected to remain a sink. Pit lake water levels are expected to recover to equilibrium, approximately 50 to 80 m lower than pre-mining groundwater levels, within about 60 years post closure (GHD 2021a).

There will be no pit lake in Crescent Moon as it is an AWT mining area.

Geochemical modelling of the expected pit lakes in both the Murray and Avon Pits has been undertaken as described in GHD (2021b) based on the geochemical properties and amount of exposed shale (Table 6-8). The modelled long term lake quality results indicate:

- Avon Pit lake
  - long-term pit lake water quality is likely to remain acidic
  - small increase in pH expected over time as the proportion of PAF runoff water relative to the other flow inputs decreases, with a pH increase from 2.5 after mine closure to 4 by 2180 (based on median likely sulphate generation rate)
  - increase in the concentration of total dissolved solids (TDS) over time, which is dominated by sulphate; TDS <2,000 mg/L at mine closure to approximately 9,000 mg/L by 2180 (based on median likely sulphate generation rate).
- Murray Pit lake
  - long-term pit lake water quality is likely to be neutral, due to a lower proportion of PAF runoff relative to other pit lake inputs.
  - increase in pH expected over time, with pH increase from 3 at mine closure rising to 7 by 2180 (based on median likely sulphate generation rate)
  - increase in the concentration of total dissolved solids (TDS) over time, which is dominated by sulphate. TDS rising from <1,000 mg/L at mine closure to approximately 3,000 mg/L by 2180 (based on median likely sulphate generation rate).
- The exposed PAF area from Ord and Nicholson Pits are small and are not expected to generate sufficient acidity to affect the water quality of the down hydraulic gradient Murray and Avon Pits.

Stratification in the pit lakes has not been included in this level of assessment. Fresh water is less dense than salty water. Therefore, it may be that relatively fresh rainfall provides a fresh layer on

top of the higher TDS water below (GHD 2021a). Following major rainfall events, large fresh rainwater water 'pulses' will flow into the pit voids, providing a significant dilution and mixing of pit lake water.

Table 6-8: Proportion of exposed PAF / NAF in pit walls

Pit name	% PAF	% NAF	Recovery modelling outcomes
Avon	45	55	Pit lake
Murray	19	81	Pit lake
Ord	21	79	Marginal (ephemeral) lake
Nicholson	4	96	Dry, except following rainfall

There is a high degree of uncertainty involved in the prediction of final pit lake water quality. However, the pits will be terminal groundwater sinks and there is poor connectivity with the regional groundwater system; therefore, there is anticipated to be no adverse impact on the surrounding groundwater quality (GHD 2021b) regardless of pit lake water quality.

The pit lake modelling indicates that the pits will not overtop into the surface water environment even in extreme rainfall events (GHD 2021b).

6.5.2.2 Surface water discharge

The groundwater quality in the aquifer to be dewatered is fresh with neutral pH and is therefore suitable for discharge to the environment.

The water quality of groundwater to be abstracted has been compared with water quality guidelines (ANZG 2018) and available data regarding surface water quality, as measured in the pools sampled by Biologic (2020a, 2022), in Appendix D and Appendix J. Baseline surface water quality data for pools downstream of the proposed dewater discharge locations on McPhee Creek, Branch of McPhee Creek and Lionel Creek is provided in Appendix H (GHD 2021d) and Appendix D (Biologic 2020a). The pool water quality data used for the comparison are the pools closest to the discharge locations in each of the three creeks; that is:

- McPhee Creek: the first two pools downstream of the proposed discharge point are used; WMPC-12 at the confluence with Branch of McPhee Creek, 15 km downstream of the discharge point; and McPC2 a further 1.5 km downstream from WMPC-12 on McPhee Creek.
- Branch of McPhee Creek: VMPC-77 was used, located about 10 km downstream of the proposed dewater discharge location.
- Lionel Creek: pool VMPC-81 was used, located about 20 km downstream of the proposed dewater discharge location.

The baseline surface water quality from these pools is based on a single sample at the surface water pools and does not provide full understanding of seasonal variability. Nevertheless, it provides an indication of the quality of the surface water quality during the rainy season.

Dewatering bores located in the deposit locations (MCP0105, MCP00152, MCP0153 and MCP0103) are used in Table 6-9. The maximum and minimum values from these bores was used for the comparison as discharge will be a blend of the groundwater pumped from these bores.

The comparison in Table 6-9 shows that the groundwater quality has similar or lower concentrations of metals, and similar pH, to the surface water pools. Therefore, the proposed discharge into the three creeks is not expected to significantly change the baseline chemical composition of the water in pools downstream of the creek discharge locations.

Table 6-9: Comparison of water quality of groundwater to be abstracted with water quality in the receiving environment (pools) and guideline values

Parameter	Site	ANZG (2018)		Baseline Surface Water Pools (Biologic 2020a)				Pit Dewater (GHD 2021d)	
				McPhee Creek		Branch of McPhee Creek	Lionel Creek	Dewatering Bores	
	Units	99% EP	95% EP	WMPC-12	MCPC2	VMPC-77	VMPC-81	Min	Max
Aluminium - Al	mg/L	0.027	0.056	0.005	0.005	25.3	26.3	0.01	0.011
Arsenic - As	mg/L	0.001	0.024	0.022	0.046	0.005	0.003	0.001	0.0011
Barium - Ba	mg/L			0.171	0.0506	0.147	0.0245	0.01	0.05
Boron - B	mg/L	0.09	0.37	0.36	1.15	0.38	0.106	0.106	1.15
Cadmium - Cd	mg/L	0.09	0.37	0.00005	0.00005	0.00005	0.00005	0.0001	0.00011
Chromium - Cr	mg/L	1E-05	0.001	.00003	0.0002	0.0002	0.0002	0.001	0.001
Copper - Cu	mg/L	0.001	0.0014	0.00075	0.00037	0.00095	0.00187	0.001	0.0011
Iron - Fe	mg/L		0.3	0.03	0.018	0.318	0.019	0.01	0.318
Manganese - Mn	mg/L	1.2	1.9	0.0398	0.125	0.389	0.0364	0.0364	1.9
Nickel - Dissolved	mg/L	0.008	0.011	0.0031	0.0015	0.0025	0.0009	0.0009	0.011
pH	pH units	6.0	8.0	8.74	8.84	8.07	8.87	8	8.87
Selenium - Se	mg/L	0.005	0.011	0.0004	0.0004	0.0004	0.0002	0.001	0.0011
Zinc - Zn	mg/L	0.0024	0.009	0.001	0.001	0.001	0.001	0.001	0.009
Total Suspended Solids	mg/L			12	5	12	5	5	12

*Notes:

0.001	Concentration is below the ANZG 99% EP guideline
0.001	Concentration is between the ANZG 99% EP guideline and 95% EP guidelines
0.001	Concentration is above the ANZG 95% EP guideline

6.5.2.3 *Alteration of surface water quality from mine runoff*

Waste dumps

Waste rock generated by the Proposal will be stored in waste dumps. As no processing of ore will occur on site, there are no proposed tailings storage facilities.

All non-shale units are geochemically benign and classified as NAF for all pits. Pyritic shale is classified as PAF and will require management to ensure that it does not affect surface water quality (Mine Earth 2021). The proposed approach is to segregate and encapsulate PAF within NAF waste material. A preliminary Mine Closure Plan is provided in Appendix A.

Surface water contamination

During construction and operation, the Proposal has the potential to contaminate surface water due to storage and handling of hazardous materials, hydrocarbons, and waste. Site drainage infrastructure will be designed to minimise or eliminate surface water runoff into areas where hydrocarbon contamination may occur. Hydrocarbon storage facilities will be appropriately constructed and bunded in accordance with Australian Standards. Facility inspection, maintenance and spill management procedures are expected to effectively mitigate the risk of contamination.

Erosion and sedimentation

Surface water runoff in the region naturally has a high sediment load given the high velocity of runoff from intense storms or cyclonic activity. Disturbed material resulting from construction and/or mining activities and areas where vegetation cover has been removed may increase the volume of sediment available to be mobilised during these events.

Where practicable, natural runoff will be diverted around operating areas, thereby limiting the volume of water required to be treated before being released to the natural environment. Where diversion of larger drainage channels is required, the design will aim to incorporate geomorphic design principles such that the natural sediment transport through the channel is maintained and the structure itself doesn't become a sediment source.

Surface water management measures will be undertaken to capture and minimise sediment runoff to undisturbed areas and drainage lines where practicable, such as using bunding and other drainage features such as silt traps and sediment basins.

6.5.3 Cumulative impacts

The groundwater drawdown extent and surface water discharge extents do not overlap with impacts from other projects. Nullagine town and surrounding pastoralists access groundwater resources downstream of the Development Envelope and will not be impacted upon by the Proposal (GHD 2021a).

The Proposal is not located near any other existing or reasonably foreseeable proposed mines, or new or significant water users. Therefore, cumulative impacts are not expected to apply with respect to inland waters.

6.6 Mitigation

During Proposal design, the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to avoid and minimise potential impacts of the Proposal to Inland Waters and

associated environmental values as far as practicable. Table 6-10 outlines measures applied to avoid and minimise potential impacts of the Proposal to Inland Waters.

Table 6-10: Application of mitigation hierarchy for Inland Waters

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: alteration of groundwater aquifers due to abstraction of groundwater	• Avoidance of mine dewatering is not possible for this Proposal. • Mining will be scheduled so that operational water demand can be supplied from mine dewatering; avoiding the need for a non-potable water supply borefield.	• The total volume of dewatering cannot be minimised. However, the Proponent is investigating an early commencement of dewatering (subject to approvals) to minimise peak dewatering rates and subsequently reduce surplus water discharge rates and wetting fronts.	• Not applicable	• Dewatering will result in long term groundwater drawdown that will extend into the surrounding plains. • No other water users or groundwater dependent pools are within the drawdown area. • Based on the very slow rate of drawdown in the underlying aquifers and the regular recharge of the alluvial systems where potential GDV occurs, the risk of impact to GDV as a result of dewatering is expected to be low.
Direct impact: alteration of hydrological regimes as a result of surplus water discharge	• Avoidance of surface water discharge is not possible for this Proposal	• As above, measures to minimise peak dewatering rates would also reduce surplus water discharge and wetting fronts. • Discharge rates will be managed between creeks to minimise impacts to pools and minimise long term mounding in alluvial aquifers.	• Not applicable	• The Proposal is expected to result in temporary alteration of the natural hydrological regime of McPhee Creek, Branch of McPhee Creek and Lionel Creek through the proposed controlled discharges to these systems. Discharge is not expected to continue

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		• Discharge locations will be constructed with scour and erosion protection. • Only water that is surplus to operational requirements will be discharged. • The Water Management Plan (Appendix B) will be implemented.		for the life of mine and the creeks will return to their natural flow regimes upon cessation of dewatering discharge. • The maximum wetting front discharge extent will be up to 15 km on McPhee Creek, 7 km in Branch of McPhee Creek and 12 km in Lionel Creek. No aquatic fauna have been identified that are limited to the discharge extents.
Direct impact: alteration of hydrological regimes as a result of mining infrastructure	• Avoidance of interruption to surface water runoff is not possible	• Surface water management during mining and closure will be designed to reduce, where practicable, adverse impacts on the natural function and environmental value of watercourses, water quality and sheet flow downstream of the mine area. • The Water Management Plan (Appendix B) will be implemented.	• Temporary infrastructure will be removed and natural flow paths, and catchments, re-established in these areas.	• The Proposal will result in the reduction of three creek catchments by approximately 10% during operations, which will then be reduced at closure. This is not expected to significantly affect the hydrological regimes of any pools.
Indirect impacts: impact to surface	• Surface water discharge of any water with potential to be	• Utilise water in operational water supply where possible.	• Establish vegetation on waste dumps to minimise erosion.	• The water quality risks associated with PAF, hydrocarbon storage

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
water quality due to mining operations	contaminated with hydrocarbons or from PAF areas will be avoided.	• Monitor water quality regularly of dewatering surplus prior to discharge as per Water Management Plan (Appendix B). • Discharge locations designed to minimise erosion risk. • PAF will be segregated and encapsulated within the waste dump. • Storage, handling and disposal of hazardous materials, waste and hydrocarbons will be in accordance with Proponent procedures. • Spills and leaks of hydrocarbons will be cleaned up in accordance with Proponent procedures.	• Perimeter bunds may be retained at closure where needed. • Waste dumps at closure will be rehabilitated to ensure they are stable and revegetated.	and erosion will be effectively assessed and managed as part of the Proposal. • Pit lakes are predicted to be a terminal sink (i.e. groundwater will flow continually towards the pit lakes, confining potential impacts to the immediate vicinity of the pit void). • Pit lakes will not overflow to surface water even during extreme flood events.

6.7 Assessment of significance of residual impacts

An assessment of the significance of residual impacts to Inland Waters as a result of the Proposal is addressed in this section. The assessment of potential impacts from abstraction and surplus discharge on other factors are also addressed under the relevant factor, e.g. impacts on riparian vegetation in flora and vegetation (Section 7), impacts to social surroundings (Section 10) and impacts on subterranean fauna habitat (Section 9).

6.7.1 Creeks

6.7.1.1 Catchment reduction

The creek catchment reductions from mining infrastructure are around 10% in McPhee Creek, Branch of McPhee Creek and Sandy Creek and some catchment flows will be reinstated at closure (Section 6.5.1.3). There is no loss of catchment in Lionel Creek and minimal loss in Spinaway Creek. The catchment losses would have a corresponding reduction in runoff and flood depth and volumes immediately downstream of the infrastructure. Given the Pilbara rainfall patterns where most rainfall is episodic with generally short periods of runoff and creek flow, a small reduction in catchment and peak flows is unlikely to change the hydrological regime to the extent that it affects any environmental values.

6.7.1.2 Controlled discharge

Controlled discharge to creeks will increase the presence and availability of surface water within the three creeks during discharge. The maximum wetting fronts are based on discharge of 15.3 GL/a, which is equal to the expected maximum dewatering rate. Concurrent discharge to all three creeks at the maximum rate for a prolonged period (total of 15.3 GL/a) is not expected to be required due to:

- Use of up to approximately 2 GL/a for operations
- The Proponent is investigating early commencement of dewatering to reduce maximum dewatering rates (noting that the total volume to be dewatered does not change). Modelling indicates this could reduce the dewatering rate by up to 8 GL/a (GHD 2021a).

Peak dewatering rates of up to 16 GL/a, if required, would only occur for one year and rates would only be above 10 GL/a for three years. During peak dewatering periods, discharge will occur to all three creeks within the assessed wetting front limits. During other years, discharge rates to each creek will be varied to provide variability in the hydrological regime with continuous flow always within the maximum wetting fronts. This approach, with flexibility to vary the discharge in the creeks, which will be more consistent with the natural variability in flow rates and less likely to create long term mounding in the alluvial aquifer which could cause waterlogging for deep rooted vegetation and an associated change to vegetation types. The creekline vegetation in the Pilbara is adapted to occasional waterlogging, however extended waterlogging may affect vegetation health. Therefore, the water management strategy has been designed to minimise prolonged flows beyond the Development Envelope. The potential impacts of discharge to flora and vegetation is addressed in Section 7.

The groundwater quality in the aquifer to be dewatered is fresh with neutral pH and is therefore suitable for discharge to the environment. The controlled discharge to McPhee Creek, Branch of McPhee Creek and Lionel Creek is not expected to have a significant impact to the environmental values along these creeks due to the short term nature of peak discharges and the current adaptation of these creeks to highly variable flows. Following cessation of

dewatering, the hydrological regimes will return to pre-mining conditions with long dry periods and slightly reduced peak flows due to catchment reduction.

6.7.2 Pools

There are 15 pools within the Development Envelope, 14 of which occur within the Conceptual Footprint, and one is within five metres of the Conceptual Footprint. As such, all 15 pools have the potential to be impacted. Despite being located within the Conceptual Footprint, the Proponent expects to be able to avoid direct impacts to three pools (i.e. WMPC 03, 22, 29), noting that a reduction in their catchments may occur resulting in a reduction of inflows and potential changes to the persistence of water in these pools.

The direct and potential indirect impacts on pools within and surrounding the Development Envelope (including long-term reference sites) are outlined in Table 6-2.

In summary,

- Permanent pools: 4 with no impacts, 3 directly impacted and 4 potentially indirectly affected
- Semi-permanent pools: 7 with no impacts and 2 directly impacted
- Seasonal/temporary pools: 12 with no impacts, 7 directly impacted and 6 potentially indirectly affected.

The majority of permanent pools are not expected to be affected by the Proposal. All pools that are within the maximum wetting front are within the last 2 km of the wetting front so only peak discharge rates will reach them. Therefore, they will not be affected by prolonged flows.

The small changes to peak flows as a result of catchment losses have been analysed with respect to flow rates and pool volumes (Table 6-11). This indicates that the pools would continue to overflow many times each year. Therefore, although the potential for indirect impacts is acknowledged, these effects are expected to be small and not significantly affect the hydrological regimes in the pools.

Table 6-11: Pool impact assessment

(Green = no impact, Yellow = potential indirect impact, Orange = Direct loss)

Pool identification	Alternative pool IDs	Direct impact?	Indirect impact	Creekline location	Permanency (Biologic 2022a)	Aquatic fauna values
McPhee Creek						
McPC2		No	Within maximum discharge extent	McPhee Creek	Permanent	
VMPC-78	McPC3	No	No	McPhee Creek	Semi-permanent	*Eodiaptomus lumholtzi* record
VMPC-79	McPC4	No	Small loss of catchment, no change to hydrological regime expected (Table 6-12)	McPhee Creek	Permanent	*Eodiaptomus lumholtzi* record *Cypretta* sp. BOS863 *Ilyodromus* sp. BOS1447
WMPC-10		No	Yes, within maximum wetting front	McPhee Creek	Temporary/ seasonal	
WMPC-11			Yes, within maximum wetting front	McPhee Creek	Temporary/ seasonal	
WMPC-12	McPC1	No	Yes, within maximum wetting front. Small loss of catchment, no change to hydrological regime expected (Table 6-12)	McPhee Creek	Semi-permanent	
WMPC-13		No	Yes, within maximum wetting front	McPhee Creek	Temporary/ seasonal	
WMPC-14		No	Yes, within maximum wetting front	McPhee Creek	Temporary/ seasonal	
WMPC-15		No	Yes, within maximum wetting front	McPhee Creek	Permanent	
WMPC-16		No	No	McPhee Creek	Temporary/ seasonal	

Pool identification	Alternative pool IDs	Direct impact?	Indirect impact	Creekline location	Permanency (Biologic 2022a)	Aquatic fauna values
WMPC-17		No	No	McPhee Creek	Temporary/ seasonal	
Lionel Creek						
UN1		No	No	Lionel Creek	Temporary/seasonal	
UN2		No	No	Lionel Creek	Temporary/seasonal	
VMPC-80	UN4	No	No	Lionel Creek	Temporary/seasonal	
VMPC-81	UN3	No	No	Lionel Creek	Permanent	*Eodiaptomus lumholtzi* record *Cypretta* sp. BOS863
Branch of McPhee Creek						
VMPC-77	BMcPC1	No	Yes, within maximum wetting front and reduced catchment	Branch of McPhee Creek	Temporary/seasonal	Freshwater turtle record *Eodiaptomus lumholtzi* record *Cypretta* sp. BOS863
VMPC-82	BMcPC4	No	Small loss of catchment, no change to hydrological regime expected (Table 6-12)	Branch of McPhee Creek	Temporary/seasonal	
VMPC-83	BMcPC3	No	Small loss of catchment, no change to hydrological regime expected (Table 6-12)	Branch of McPhee Creek	Semi-permanent	Freshwater turtle record
VMPC-84	BMcPC2	No	No	Branch of McPhee Creek	Semi-permanent	Freshwater turtle record
Range pools						
WMPC-01		Yes	-	Sandy Creek	Permanent	Cyprididae 'sp. Biologic-OSTR038, Cyprididae 'sp. Biologic-OSTR039

Pool identification	Alternative pool IDs	Direct impact?	Indirect impact	Creekline location	Permanency (Biologic 2022a)	Aquatic fauna values
WMPC-02		Yes	-	Sandy Creek	Temporary/ seasonal	
WMPC-03		Expected to be avoided	Yes, majority catchment loss	Sandy Creek	Permanent	Cyprididae 'sp. Biologic-OSTR038
WMPC-04		No	Small loss of catchment, no change to hydrological regime expected	Sandy Creek	Temporary/ seasonal	
WMPC-05		No	Small loss of catchment, no change to hydrological regime expected	Sandy Creek	Permanent	
WMPC-06		No	Small loss of catchment, no change to hydrological regime expected	Sandy Creek	Temporary/ seasonal	
WMPC-07		No	Small loss of catchment, no change to hydrological regime expected	Sandy Creek	Temporary/ seasonal	
WMPC-08	Range 1	Yes	-	Sandy Creek	Permanent	*Newnhamia* sp. BOS1197, Cyprididae 'sp. Biologic-OSTR039, Cyprididae 'sp. Biologic-OSTR035
WMPC-09	Range 2	Yes	-	Lionel Creek	Permanent	*Anisops nabillus* *Newnhamia* sp. BOS1197, Cyprididae 'sp. Biologic-OSTR035, Cyprididae 'sp. Biologic-OSTR039

Pool identification	Alternative pool IDs	Direct impact?	Indirect impact	Creekline location	Permanency (Biologic 2022a)	Aquatic fauna values
WMPC-18		No, inside SFEZ	No	Spinaway Creek	Semi-permanent	
WMPC-19		No, inside SFEZ	No	Spinaway Creek	Temporary/ seasonal	
WMPC-20		No, inside SFEZ	No	Spinaway Creek	Temporary/ seasonal	
WMPC-21	Range 3	No, inside SFEZ	No	Spinaway Creek	Permanent	*Anisops nabillus*, *Cyprididae 'sp. Biologic-OSTR037*, *Cyprididae 'sp. Biologic-OSTR039* *Newnhamia* sp. BOS1197
WMPC-22		Expected to be avoided	Yes, majority catchment loss	Sandy Creek	Permanent	
WMPC-25		Yes	-	Lionel Creek	Semi-permanent	
WMPC-26		Yes	-	Lionel Creek	Temporary/ seasonal	
WMPC-27		Yes	-	Lionel Creek	Semi-permanent	
WMPC-28		Yes	-	Sandy Creek	Temporary/ seasonal	
WMPC-29		Expected to be avoided	Yes, majority catchment loss	Sandy Creek	Temporary/ seasonal	
WMPC-30		Yes	-	Sandy Creek	Temporary/ seasonal	
WMPC-31		Yes	-	Lionel Creek	Temporary/ seasonal	
WMPC-32		No, inside SFEZ	No	Sandy Creek	Temporary/ seasonal	
WMPC-33		Yes	-	Sandy Creek	Temporary/ seasonal	
WMPC-34		Yes	-	Spinaway Creek	Temporary/ seasonal	

Pool identification	Alternative pool IDs	Direct impact?	Indirect impact	Creekline location	Permanency (Biologic 2022a)	Aquatic fauna values
Long-term reference sites						
Garden Pool		No	No	Nullagine River	Semi-permanent	
Daylight Pool		No	No	Nullagine River	Semi-permanent	

The volume of some pools was estimated by Biologic (2020a) and the results that are available indicate the pool volumes are small in comparison to average annual flows (Table 6-12). Therefore, even with catchment reductions, the creek flows at these locations remain magnitudes higher than the storage capacities of the pools and therefore will continue to overtop many times in a flow event. Following any rainfall event, the pools would be expected to dry out, from full, at the same rate as normal.

Table 6-12: McPhee Creek change in average annual stream flow volumes at pools, baseline compared to operation

Pool	Pool volume*	Catchment area		Runoff volume		Runoff as percentage of pond volume	
		Baseline	Operation	Baseline	Operation	Baseline	Operation
	m^3	ha	ha	m^3	m^3	%	%
McPC1	84	2,502	1,956	1,469,925	1,149,150	17,499	13,680
McPC2	4,400	3,944	3,398	2,317,100	1,996,325	527	454
McPC3	8,000	4,820	4,274	2,831,750	2,510,975	354	314
McPC4	6,000	4,853	4,307	2,851,138	2,530,363	475	422
BMcPC1	1,000	11,746	10,398	6,900,775	6,108,825	6,901	6,109
BMcPC2	2,250	12,258	10,910	7,201,575	6,409,625	3,201	2,849
BMcPC3	160	14,875	13,527	8,739,063	7,947,113	54,619	49,669
BMcPC4	840	15,485	14,117	9,097,438	8,293,738	10,830	9,873
Range 1	2	78	58	91,650	68,150	57,281	42,594
Range 2	8	12	11	14,100	12,690	1,808	1,627

*Pool volumes as per Biologic 2020a

6.7.3 Aquatic fauna

Five freshwater fish species were recorded during recent surveys, with all species considered common and widespread in the Pilbara. Four species were recorded in all creeks sampled, with the Murchison River hardyhead recorded in McPhee Creek. All fish species were recorded from creeks located outside the Development Envelope, with no fish recorded in the Range Pools located within the Development Envelope. Given the above, no significant impacts are expected to fish species.

The freshwater turtle *Chelodina steindachneri* was recorded in three pools of Branch of McPhee Creek. The species is not of conservation significance. Two of the three records were within pools that are within the maximum wetting front along Branch of McPhee Creek. Breeding for the turtles has been observed to coincide with rainfall and increased surface flows in the wet season (Biologic 2020a) and therefore discharge could affect the turtles by triggering out of season breeding. The duration of peak discharge, if required, is expected to be short (less than one year) and therefore, the hydrological regime would only be temporarily affected. Given the adaptability of the turtles to highly variable flows, there is not expected to affect their persistence in branch of McPhee Creek.

A total of 14 aquatic invertebrate fauna species of interest were recorded during recent surveys (refer to Section 6.3.7). The majority of these species have been recorded from sites located outside the Conceptual Footprint, with nine species recorded from sites located outside the

Development Envelope, including: *Eodiaptomus lumholtzi*, *Cypretta* sp. BOS863, *Ilyodromus* sp. BOS1447, Cyprididae sp. Biologic-OSTR040`, *Hemicordulia koomina*, *Eurysticta coolawanyah*, Cyprididae' sp. Biologic-OSTR037, Cyprididae 'sp. Biologic-OSTR041' and Cyprididae 'sp. Biologic-OSTR040' (Table 6-13). Given these species occurrence in areas outside the impact areas, and outside the Development Envelope, no significant impact is expected to occur to any of these nine species.

Three species were recorded from areas inside and outside the Conceptual Footprint including *Newnhamia* sp. BOS1197, *Anisops nabillus* and Cypridiae 'sp. Biologic-OSTR039' (Table 6-13). Given that these species are known to occur outside the impact areas, no significant impact is expected to occur to any of these three species.

Two species were only recorded from sites located within the Conceptual Footprint, where they may be at risk of direct or indirect impacts associated with the Proposal;Cyprididae 'sp.Biologic-OSTR035' and Cyprididae 'sp. Biologic-OSTR038' (Table 6-13). These species are discussed in further detail below.

Table 6-13: Aquatic fauna species potentially at risk

Species and site	Inside Conceptual Footprint	Outside Development Envelope	Risk of impact
Eodiaptomus lumholtzi			
VMPC-78 (McPC3)	No	Yes	No
VMPC-79 (McPC4	No	Yes	No
VMPC-77 (BMcPC1),	No	Yes	No
VMPC-81 (UN3)	No	Yes	No
Daylight Pool	No	Yes	No
VMPC-84 (BMcPC2)	No	Yes	No
***Cypretta* sp. BOS863**			
VMPC-79	No	Yes	No
VMPC-77	No	Yes	No
VMPC-81	No	Yes	No
***Ilyodromus* sp. BOS1447**			
Daylight Pool	No	Yes	No
VMPC-79	No	Yes	No
Cyprididae sp. Biologic-OSTR040`			
VMPC-79	No	Yes	No
Hemicordulia koomina			
UN2	No	Yes	No
Daylight Pool	No	Yes	No
VMPC-81	No	Yes	No
Eurysticta coolawanyah			
WMPC-12	No	Yes	No
VMPC-81	No	Yes	No
***Newnhamia* sp. BOS1197**			

Species and site	Inside Conceptual Footprint	Outside Development Envelope	Risk of impact
WMPC-08	Yes	No	Potential risk
WMPC-09	Yes	No	Potential risk
WMPC-21*	No	Yes	No
Anisops nabillus			
WMPC-01	Yes	No	Potential risk
WMPC-03	Yes	No	Potential risk
WMPC-05	No	No	No
WMPC-08	Yes	No	Potential risk
WMPC-09	Yes	No	Potential risk
WMPC-21	No	No	No
Cyprididae 'sp.Biologic-OSTR035			
WMPC-08	Yes	No	Potential risk
WMPC-09	Yes	No	Potential risk
Cyprididae' sp. Biologic-OSTR037			
WMPC-21	No	No	No
Cyprididae 'sp. Biologic-OSTR038			
WMPC-01	Yes	No	Potential risk
WMPC-03	Yes	No	Potential risk
Cypridiae 'sp. Biologic-OSTR039'			
WMPC-01	Yes	No	Potential risk
WMPC-08	Yes	No	Potential risk
WMPC-09	Yes	No	Potential risk
WMPC-21*	No	No	No
Cyprididae 'sp. Biologic-OSTR041'			
WMPC-12	No	Yes	No
VMPC-77	No	Yes	No
VMPC-84	No	Yes	No
Cyprididae 'sp. Biologic-OSTR040'			
VMPC-79	No	Yes	No

* Site located within the SFEZ

6.7.3.1 Cyprididae 'sp.Biologic-OSTR035'

The ostracod Cyprididae sp. 'Biologic-OSTR035 was recorded from two Range Pools (WMPC-08 and WMPC-09) located within the proposed pit areas within the Conceptual Footprint (Figure 6-9). This taxon has not been previously recorded and there were no similar sequences in the available database. However, given the nature of ostracods (i.e. high mobility under high flow events) and the limited habitat available in these pools (refer Plate 6-1), it is considered highly unlikely that these records represent the full distribution of this species.

6.7.3.2 *Cyprididae 'sp. Biologic-OSTR038'*

The ostracod Cyprididae 'sp. Biologic-OSTR038 was recorded from two Range Pools (WMPC-01 and WMPC-03), both of which are located within the Conceptual Footprint (Figure 6-9). Based on current knowledge, this species has a linear range of 800 m and is restricted. However, given the nature of ostracods (i.e. high mobility under high flow events) and the limited habitat available in these pools), it is considered highly unlikely that these records represent the full distribution of this species.

6.7.4 Potentially groundwater dependent vegetation

The risk of impact to potential GDV increases with drawdown (both the quantum and rate of drawdown) and decreases with pre-mining depth to groundwater (as vegetation is more likely to access shallow watertables). Potential GDV areas have been mapped by Ecoscape (2020a) and occur in the riparian zones of creeklines. Ecoscape (2020a) notes that where the depth to groundwater is more than 10 m, vegetation is only likely to access groundwater opportunistically.

The rate of drawdown will also affect the likelihood and severity of potential impacts to GDV (Froend and Loomes 2004). The rate of drawdown in the fractured rock aquifer areas beyond the McPhee Creek ridge is predicted to be very slow as there is low transmissivity beyond the orebody aquifers. Therefore, the maximum drawdown is not expected to occur for hundreds of years. The modelled groundwater drawdown at four locations outside the Conceptual Footprint is shown in the chart below (Figure 6-22) and the rate of drawdown over time is shown in Figure 6-23. The modelled rate of drawdown at one location in the upper reaches of branch of McPhee Creek (location shown on Figure 6-24) reaches 6 cm/yr whereas the other three locations have rates of drawdown of less than 2 cm/yr. These modelled rates relate only to drawdown in the fractured rock aquifer and do not represent changes in watertable in alluvial aquifers.

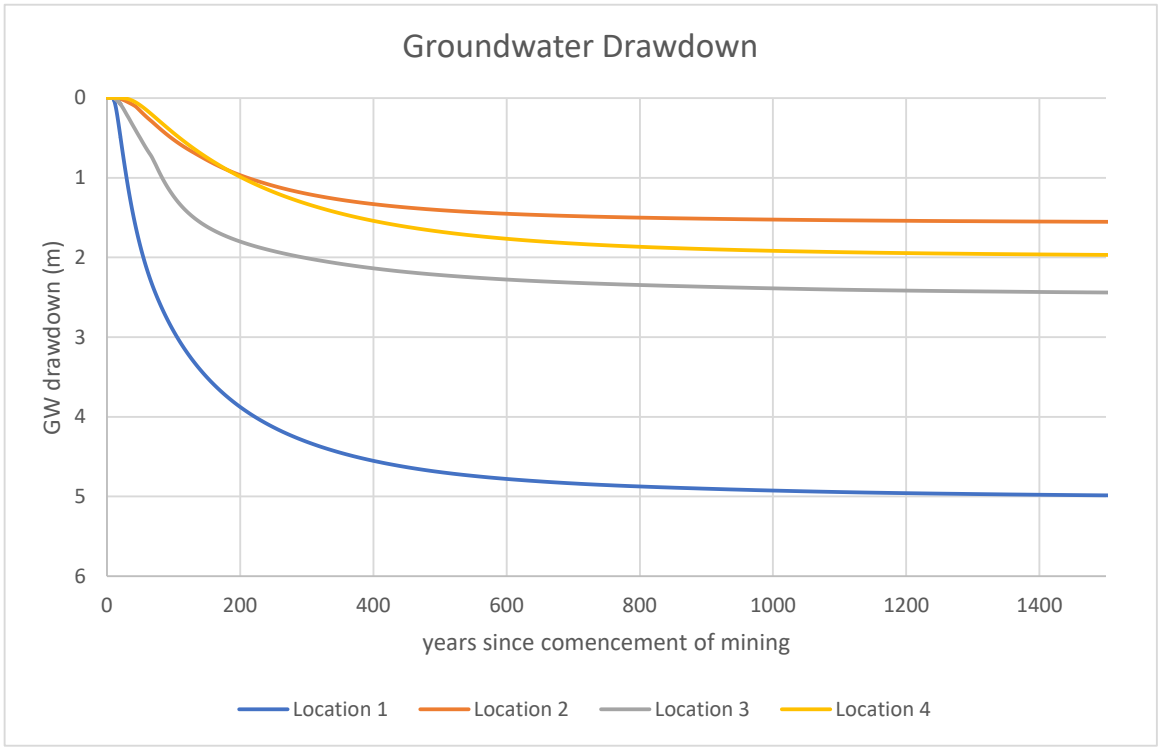

Figure 6-22: Hydrograph of modelled deep groundwater response to dewatering at selected locations

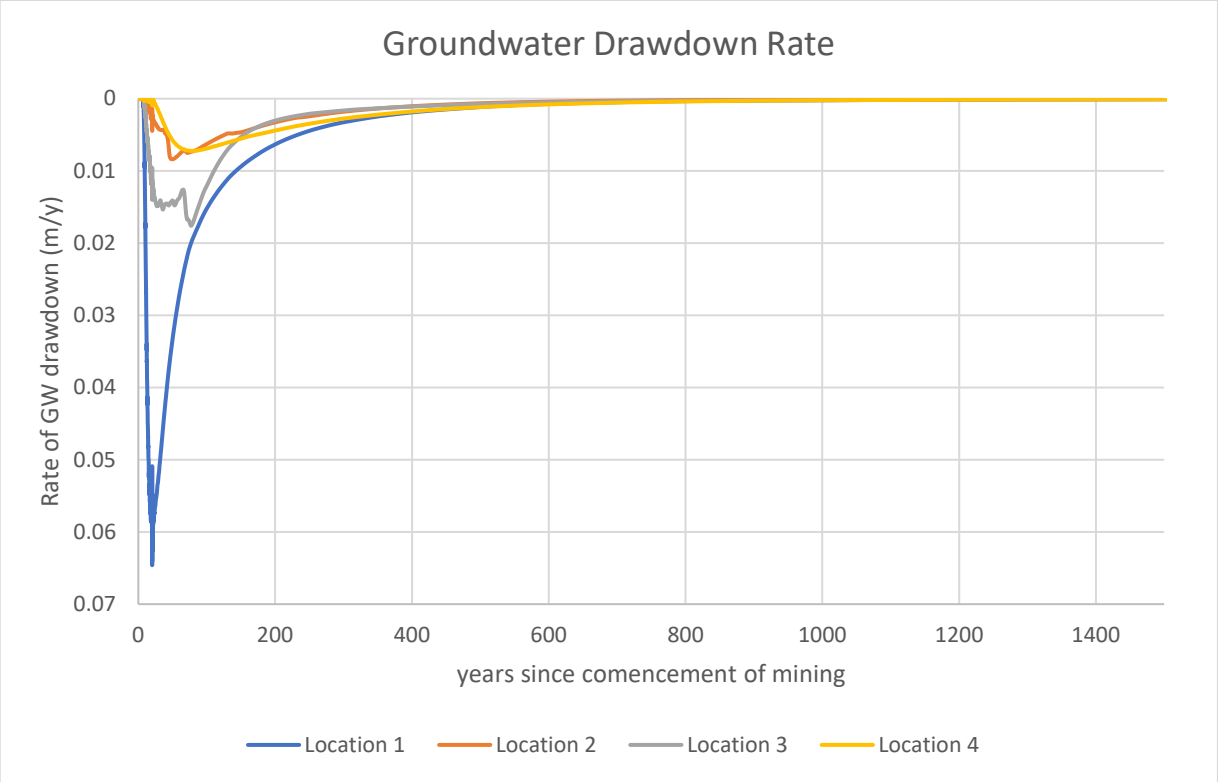

Figure 6-23: Modelled rate of drawdown at selected locations

There is 51.4 ha of potential GDV (of which 47.5 ha is located in the Development Envelope) that is within areas with shallow watertables (<10 m bgl) where drawdown in the underlying fractured rock aquifer of greater than 2 m is predicted. These areas are highlighted in yellow in Table 6-14. However, these areas are associated with creekline vegetation and likely access alluvial aquifers. Vegetation health in these areas is unlikely to be significantly affected as the maximum rate of drawdown in the underlying fractured rock aquifer is 6 cm/year and at these rates (if they did occur) vegetation would be likely to be able to adapt at this rate. However, the alluvial aquifers are topped up by direct recharge from rainfall and creek flows after every major rainfall event. This localised recharge would naturally mitigate any change in water levels in the alluvial aquifer that could occur due to leakage into the underlying fractured rock aquifer. This localised recharge to alluvial aquifers is not accounted for in the groundwater modelling by GHD (2021a).

Based on the very slow rate of drawdown in the underlying aquifers and the regular recharge of the alluvial systems where potential GDV occurs, the risk of impact to GDV as a result of dewatering is expected to be low. Minor changes to vegetation health within potential GDV areas inside the Development Envelope could potentially occur (47.5 ha) as discussed in Section 7.4.2.3. Beyond the Development Envelope, the rates of drawdown in potential GDV areas are modelled to be less than 1-2 cm/yr and therefore there is negligible potential for change in these areas.

Table 6-14: Extent and magnitude of the long term post closure drawdown in areas of potential GDV

Pre-mining depth to groundwater (mbgl)	Area (ha) of potential GDV within each drawdown band		
	Drawdown 1-2 m (negligible change)	Drawdown 2-5 m	Drawdown of 5+ m
0-5 m	16.9	23.3	6.2
5-10 m	3.4	16.2	5.7
10-15 m (opportunistic GDV)	1.6	3.2	5.8

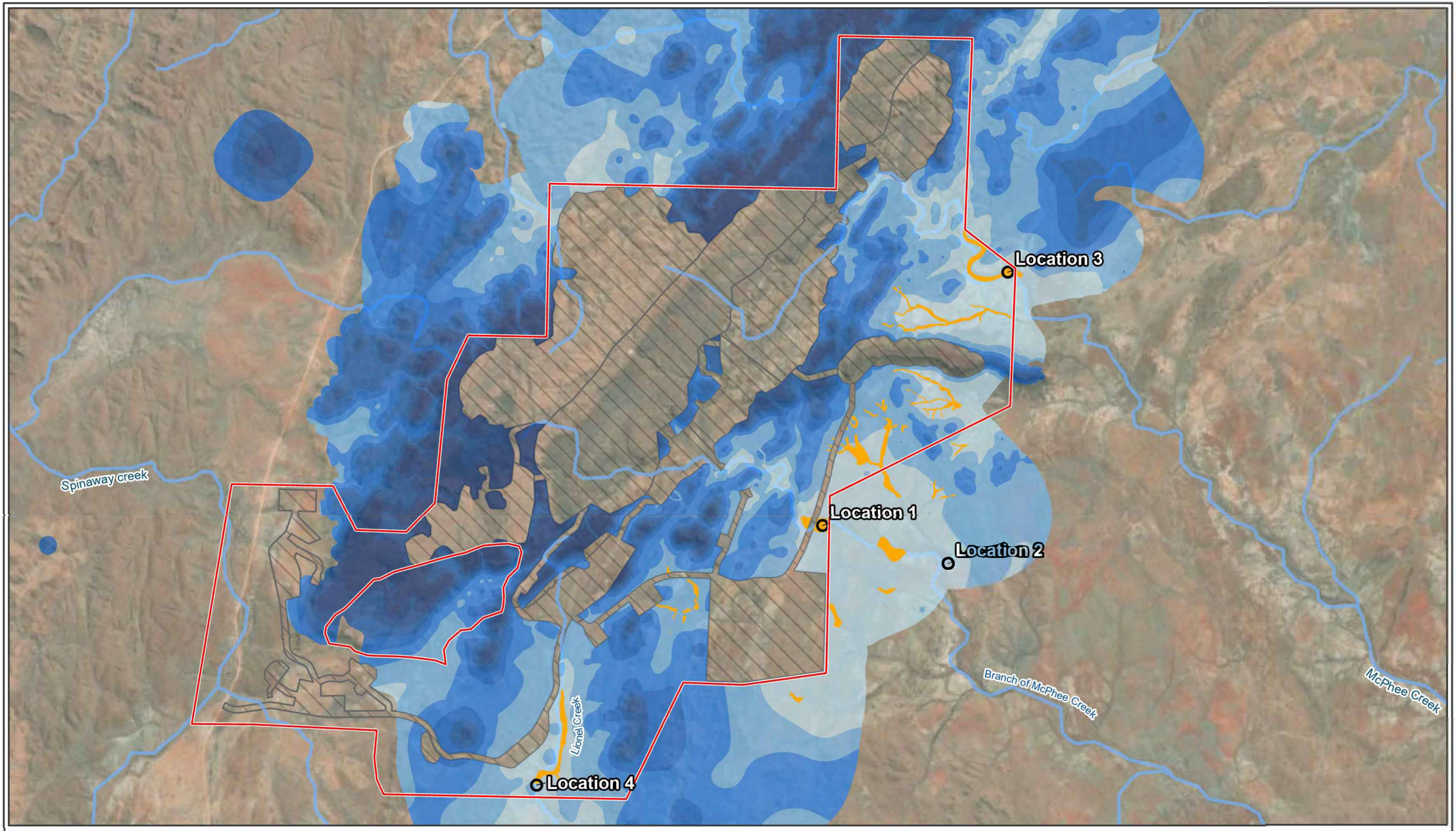

Figure 6-24: Extent of Potential GDV in groundwater drawdown areas

Development Envelope
Conceptual Footprint
Drainage
Potential GDV with >2m drawdown

Groundwater depth Contours

0-10m
11-20m
21-30m
31-40m
41-50m
51-60m
61-70m
71-80m
81-90m
90m+

0 0.5 1 2
Kilometers

Datum/Projection:
GDA 1994 MGA Zone 50
Project: 15064-DD Date: 13/04/2022

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6.7.5 Other water users

Groundwater level change associated with dewatering is predicted to occur within a relatively narrow region along the orebody. There are no known licensed groundwater users within the cone of depression developed during dewatering or post closure. Therefore, no impact to licenced groundwater users is anticipated in the area (GHD 2021a), although unlicensed users may be affected if present within drawdown extent.

Nullagine town water supply is approximately 30 km from the Development Envelope and beyond the area of groundwater drawdown predicted to occur as a result of the Proposal.

6.7.6 Indirect impacts to water quality

6.7.6.1 Post closure formation of permanent or ephemeral pit lakes

The modelled long term pit lake quality results indicate:

- Avon Pit: acidic with an increase in TDS over time; dominated by sulphate
- Murray Pit: likely to be neutral in the long term with a lower proportion of PAF runoff relative to other runoff inputs to the lake.

There is uncertainty involved in the prediction of final pit lake water quality. However, the pits will be terminal groundwater sinks and therefore there is anticipated to be no adverse impact on the surrounding groundwater quality (GHD 2021b) regardless of pit lake water quality. In addition, the pre-mining depth to groundwater in the mining areas is greater than 40 m and there is no groundwater dependent vegetation that could be affected. The pit lake modelling indicates that the pits will not overtop into the surface water environment even in extreme rainfall events (GHD 2021b). Therefore, no environmental values are expected to be affected by the formation of pit lakes.

6.7.6.2 Surface water discharge

The groundwater to be discharged is fresh, neutral pH and without nutrient enrichment or elevated levels of metals. The groundwater has similar or lower concentrations of metals to the surface water pools. Therefore, the groundwater is suitable for discharge to the environment And the proposed discharge into the three creeks is not expected to significantly change the baseline chemical composition of the water in pools downstream of the creek discharge locations.

The baseline water quality of the pools includes nutrient enrichment and sometimes low dissolved oxygen; therefore, the addition of low nutrient groundwater may provide a short term improvement in water quality.

The key environmental receptor for any water quality changes in pools are aquatic fauna. As no aquatic fauna species are limited to the impact area, there is not expected to be any loss of aquatic diversity in the region as a result of surface water discharge.

6.7.6.3 Waste dumps

The majority of waste will come from non-shale units which are classified as NAF (Section 6.3.5). The pyritic shale units have been identified as PAF and will require management. The proposed approach is to segregate and encapsulate PAF within NAF waste material. There is sufficient NAF material and established methodologies available to effectively manage PAF and prevent acid mine drainage from waste dumps.

6.7.6.4 Increased sediments from infrastructure, drainage and discharge

The potential for increased sediment loads in runoff is expected to be effectively managed. Dewatering surplus will have been settled prior to discharge and is expected to have very low turbidity. Discharge points in the creeks will be designed so that discharge flow velocities do not create erosion in the receiving environment.

6.7.6.5 Storage and handling of hazardous materials and waste.

Site drainage infrastructure will be designed to minimise or eliminate surface water runoff into areas where hydrocarbon contamination may occur and to account for potential future increases in rainfall (GHD 2021d). Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas. Storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge.

Spills and leaks of hydrocarbons will be cleaned up in accordance with internal procedures and contaminated soils remediated or disposed of in accordance with internal procedures.

6.8 Environmental outcomes

The predicted impacts to Inland Waters from the Proposal after applying the mitigation hierarchy include formation of pit lakes, groundwater drawdown and modification of creek hydrological regimes.

Permanent pit lakes will form in Avon and Murray pits, with marginal lakes in parts of the Ord Pit. Pit lakes will be groundwater sinks with respect to regional groundwater flows and will therefore not affect surrounding groundwater quality.

Groundwater drawdown is mostly contained within the orebody aquifer beneath the Main Range; however, drawdown does extend slowly into the fractured rock aquifer underlying the surrounding plains. Approximately 51.4 ha of potential GDV is within the long term groundwater drawdown area (>2 m drawdown) in areas with pre-mining depth to groundwater of <10 m. Based on the very slow rate of drawdown in the underlying aquifers (<6 cm/yr) and the regular recharge of the alluvial systems where potential GDV occurs, the risk of impact to GDV as a result of dewatering is expected to be low. Outcomes associated with drawdown and subsequent impacts on GDV are discussed in Section 7.6.2.3. Beyond the Development Envelope, the rates of drawdown in potential GDV areas are modelled to be less than 1-2 cm/yr and therefore there is negligible potential for change in these areas.

No groundwater dependent pools or other licenced groundwater users are within the area of drawdown.

The pyritic shale units have been identified as PAF and excavated shales will require management. PAF will be segregated and encapsulated within the waste dump. This is an established approach to effectively manage PAF and prevent acid mine drainage.

The direct and potential indirect impacts on pools within and surrounding the Development Envelope (including long-term reference sites) are outlined in Section 6.7.2.

In summary,

- Permanent pools: Four with no impacts, three directly impacted and four potentially indirectly affected
- Semi-permanent pools: Seven with no impacts and two directly impacted

- Seasonal/temporary pools: 12 with no impacts, 7 directly impacted and 6 potentially indirectly affected.

The majority of aquatic fauna species occur outside the Conceptual Footprint and/or outside the Development Envelope and are not at risk of impact from the Proposal. Two species are currently only known from the Conceptual Footprint; Cyprididae 'sp.Biologic-OSTR035' and Cyprididae 'sp. Biologic-OSTR038'. Given the nature of ostracods (i.e. high mobility under high flow events) and the limited habitat available in the they were recorded from, it is considered highly unlikely that these records represent the full distribution of this species.

The maximum wetting fronts for each creek are:

- 15 km in McPhee Creek
- 7 km in Branch of McPhee Creek
- 12 km of Lionel Creek.

Controlled discharge to these creeks will not be continuous and peak discharge will only occur early in mine life. Discharges are not expected to have a significant impact to the environmental values along these creeks due to the short term nature of peak discharges and the adaptation of these creeks to highly variable flows.

6.9 Conclusion

The residual impacts of the Proposal to Inland Waters are not considered significant. The Proponent therefore considers the Proposal can be managed to meet the EPA's objective *to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected*.

7 Flora and Vegetation

7.1 EPA environmental factor objective

The EPA's objective for flora and vegetation is to *protect flora and vegetation so that biological diversity and ecological integrity are maintained* (EPA 2021c).

For this EIA, flora is defined as native vascular plants and vegetation is defined as groupings of different flora patterned across the landscape that occur in response to environmental conditions (EPA 2016e). Significant flora and vegetation are defined as any flora species or vegetation community protected under legalisation, listed as Priority under DBCA or important locally. Protected species may be considered significant for a variety of reasons, including (but not limited to) narrow distribution, new or potential new species, species that are locally endemic, or vegetation that has an important role in the ecosystem (EPA 2016a).

7.2 Relevant policy and guidance

The relevant policy and guidance for Flora and Vegetation are described in (Table 7-1).

Table 7-1: Relevant Policy and Guidance for Flora and Vegetation

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
Environmental Protection Authority	
Instructions on how to prepare an Environmental Review Document (EPA 2021d)	Considered during the development of this document
Statement of Environmental Principles, Factors and Objectives (EPA 2021c)	
Environmental Factor Guideline: Flora and Vegetation (EPA 2016a)	Considered in the design (methods and approach) of the flora and vegetation surveys or previous guidance (if survey undertaken before current guidelines)
Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016e)	
Instructions on how to prepare environmental Protection Act 1986 Part IV Impact Reconciliation Procedures and Impact Reconciliation Reports (EPA 2021a)	Considered in the development of this document and for the Impact Reconciliation Procedure (Appendix K)
Template for Environmental Protection Act 1986 Part IV Reconciliation Procedures (EPA 2021b)	
Other State or Commonwealth	
DMIRS Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines (DMIRS 2020c)	Considered in the development of this document and for the Mine Closure Plan (Appendix A)
Statutory Guidelines for Mine Closure Plans (DMIRS 2020b)	
Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986 (EPA 2014)	Considered in the impact assessment and offset strategy for flora and vegetation

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
WA Environmental Offsets Policy (GoWA 2011)	
WA Environmental Offsets Guidelines (GoWA 2014).	

With effect from 1 January 2019, the *Biodiversity Conservation Act 2016* (BC Act) and Biodiversity Conservation Regulations 2018 replaced the *Wildlife Conservation Act 1950* (WC Act) and associated regulations. Threatened flora taxa listed as Specially Protected under the WC Act are now recognised as Threatened under the BC Act. Threatened Ecological Communities (TECs) previously endorsed by the Minister for Environment can now be formally listed as TECs under the BC Act.

Technical studies undertaken for the Proposal prior to 2019 will refer to the Acts in force at the time; however, these are supplemented by more recent comprehensive studies completed in 2020.

7.3 Receiving environment

7.3.1 Studies and survey effort

The existing environment in the Development Envelope is well understood. Numerous surveys have been conducted over a number of years including baseline surveys and targeted conservation significant species surveys.

Surveys first commenced in the Development Envelope in 2012 in relation to a previous development concept. Woodman Environment Consulting (Woodman 2012) conducted a detailed Level 2 terrestrial flora and vegetation baseline survey. The results of this survey informed a subsequent riparian vegetation survey (Woodman 2014a) and conservation significant species survey (Woodman 2013).

Since that time, the Proposal has been substantially revised and given the amount of time lapsed, a further comprehensive single phase detailed flora and vegetation survey was conducted in 2020 (Ecoscape 2020a; Appendix L). To address minor gaps in survey coverage, vegetation type and condition have been extrapolated, drawing upon high resolution aerial imagery, review of existing quadrat data from adjacent areas and observations made during the 2019 field survey by Ecoscape (2020b; Appendix L).

A summary of survey effort is provided in Table 7-2 and depicted in Figure 7-1, with key surveys provided as appendices. All surveys have been conducted in accordance with the relevant guidance outlined in Section 7.2.

Table 7-2: Flora and vegetation surveys of the Development Envelope

Survey	Assessment type	Summary of survey effort and outcomes
McPhee Creek Project Flora and Vegetation Desktop Review (Woodman 2011)	Desktop assessment	Desktop assessment of flora and vegetation including review of local flora and vegetation surveys, to identify potential significant values in the survey area and recommend survey effort.
McPhee Creek Project Flora and Vegetation Assessment (Woodman 2012)	Field survey	Level 2 detailed flora and vegetation survey conducted in May 2012. The survey identified vegetation types, conservation significant flora and communities, introduced weed species, vegetation condition, potential groundwater dependent ecosystems. The survey identified three Priority flora species. No threatened species or communities listed as MNES were identified in the survey area.
McPhee Creek Iron Ore Project Conservation Significant Flora Assessment (Woodman 2013)	Field survey	Targeted flora and vegetation survey to search for conservation significant taxa including three Priority species previously identified in the survey area and occurrences of one PEC. The survey confirmed the presence of three state listed Priority species and no other conservation significant species or communities.
McPhee Creek Iron Ore Project Riparian Vegetation Mapping (Discharge options 1, 2 and 3) (Woodman 2014a)	Field survey	Detailed mapping of riparian vegetation types and condition along three creeklines which were potential discharge options considered for previous proposal concept. The survey mapped vegetation types, condition, conservation significant flora and identified weed species. The survey identified one state listed Priority flora species. No threatened species or communities were identified within the survey area.
McPhee Creek Detailed Flora and Vegetation Assessment (Woodman 2019a)	Desktop assessment	Desktop assessment and review of three previous field surveys undertaken in 2012 and 2013. No field survey was undertaken.
McPhee Creek Flora and Vegetation Survey (Ecoscape 2020a; Appendix L)	Field survey	Desktop assessment, gap analysis and single-phase detailed flora and vegetation survey conducted over 11 days in April 2020. The survey mapped vegetation types, condition, and identified priority flora. No TECs or flora listed as MNES were identified during the survey.
McPhee Creek Flora and Vegetation Survey Addendum (Ecoscape 2020b; Appendix L)	Desktop assessment	Desktop assessment to extrapolate vegetation condition, type and Groundwater Dependent Vegetation mapping to accommodate for small changes made to the original Development Envelope. No TECs or PECs were identified in the expanded survey area. One state listed Priority species and one potential groundwater dependent ecosystem were identified.

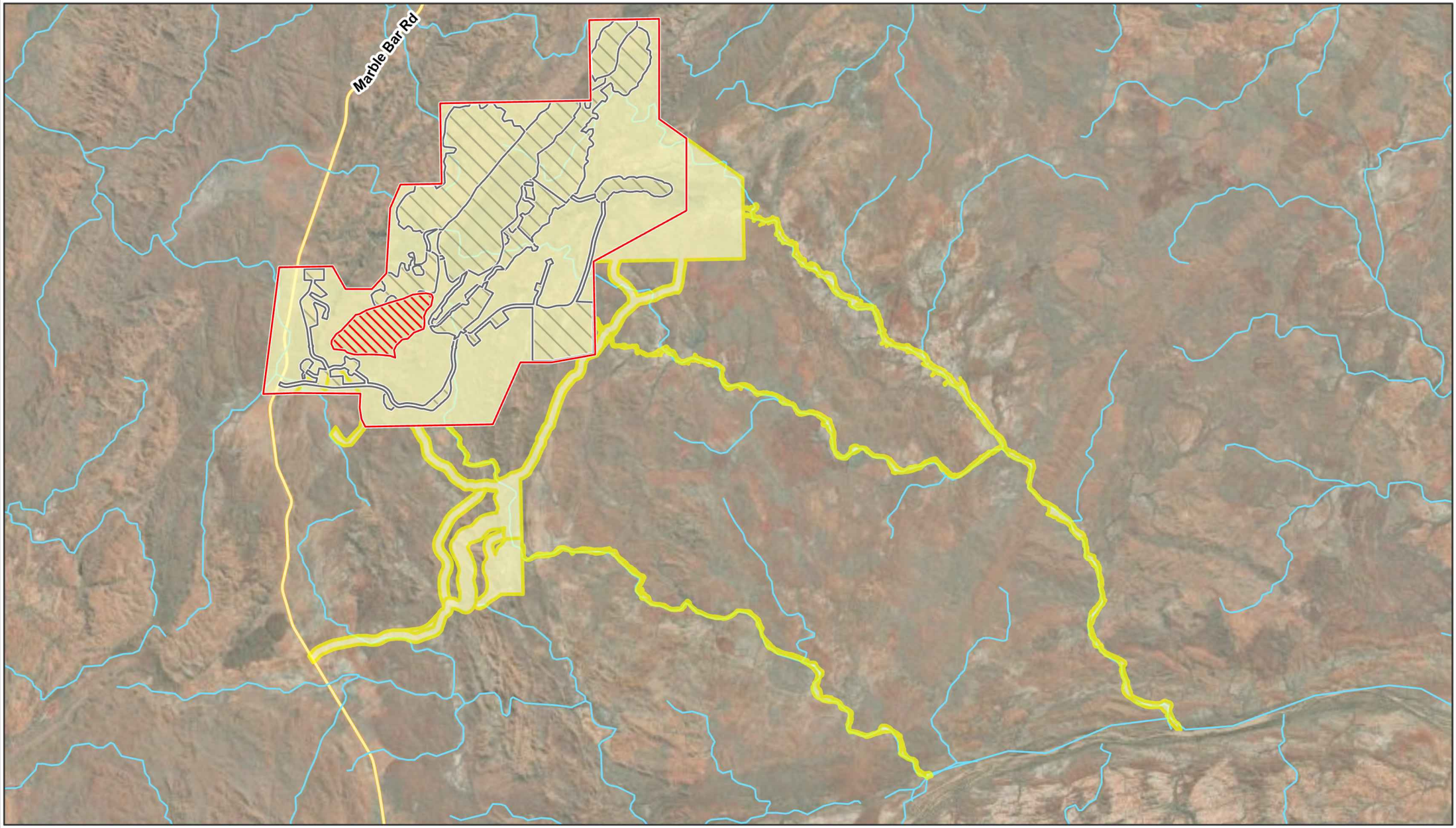

Figure 7-1: Flora and vegetation survey effort within and surrounding the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone
Flora & Vegetation Survey Boundary

0 1 2 4
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

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7.3.2 Vegetation

7.3.2.1 IBRA region

Vegetation occurring within the Pilbara region was mapped at a broad scale (1:1,000,000) during the 1970s (Beard 1975). This dataset formed the basis of several regional mapping systems, including the interim biogeographical regionalisation for Australia (IBRA) dataset for Western Australian physiographic regions (DoEE 2017). The Development Envelope is situated within the Pilbara bioregion, of which 8.4% is represented in the national reserve system. The Development Envelope is located in the Chichester sub-region, which is described as:

> *The Chichester subregion (PIL 1) 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 (formerly Triodia pungens) 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, Sherlock). Subregional area is 9,044,560 ha.*

7.3.2.2 Land Systems

The Department of Primary Industries and Regional Development (DPIRD) has mapped and described the land systems of Western Australian rangelands, providing a comprehensive description of biophysical resources, including soil and vegetation condition. Four land systems associated with the Chichester subregion occur within the Development Envelope (Table 7-3), with the Capricorn land system accounting for approximately 50% of the Development Envelope.

Table 7-3: Land systems within the Development Envelope

Land System	Current extent within the Chichester subregion		Approximate current extent within conservation estate*	Total extent within the Development Envelope	
	ha	%	%	ha	%
Capricorn - Hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands.	482,779	5.8	44	2,449	0.5
Robe - Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands.	25,182	0.3	1	214	0.8
Rocklea - Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	2,123,354	25.4	42	1,545	0.1

Land System	Current extent within the Chichester subregion		Approximate current extent within conservation estate*	Total extent within the Development Envelope	
	ha	%	%	ha	%
Taylor - Stony plains and isolated low hills of sedimentary rocks supporting hard and soft spinifex grasslands.	11,046	0.1	71	257	2.3
TOTAL				**4,465**	

*Approximate extent of occurrence within Ex Meentheena Nature Reserve and Mungaroona Range Nature Reserve. Estimates of land systems within conservation estate were approximated by calculating the total area of each land system within the National Reserve System using the collaborative Australian Protected Area Database (CAPAD) (DAWE 2020).

7.3.2.3 Vegetation associations

Two pre-European vegetation association units are represented by the vegetation in the Development Envelope (Ecoscape 2020a). Table 7-4 summarises the current and pre-European extent of these vegetation associations within the Chichester subregion and the Development Envelope. More than 99% of the pre-European extent of each of these associations remain across the Chichester subregion.

Table 7-4: Vegetation associations within the Development Envelope

Vegetation association	Extent within the Chichester subregion			Pre-European extent within conservation estate	Extent within the Development Envelope	
	Pre-European (ha)	Current (ha)	% remaining	%	ha	% pre-European extent
171: Hummock grasslands, low tree steppe; snappy gum over soft spinifex and Triodia brizoides.	331,307.4	330,026.2	99.6	-	1,956	0.6
173: Hummock grasslands, shrub steppe; kanji over soft spinifex and Triodia wiseana on basalt.	1,744,029.5	1,739,189.6	99.7	7.5	2,509	0.1
Total					**4,465**	

7.3.2.4 Vegetation types and condition

The majority of vegetation (approximately 91%) in the Development Envelope is in Excellent condition; however, overall condition ranges from Excellent to Good and Cleared (not vegetated) (Figure 7-3).

Key disturbances which influenced condition of vegetation included historical grazing, drill lines and exploration tracks; and weed invasion. Table 7-5 provides details of the vegetation condition in the Development Envelope.

Table 7-5: Vegetation condition in the Development Envelope

Vegetation condition	Extent in Development Envelope (ha)	% of Development Envelope
Excellent	4,081.6	91.4
Good	376.7	8.4
Cleared (not vegetated)	6.7	0.2
TOTAL	**4,465**	**100**

Sixteen vegetation types were mapped within the Development Envelope (Ecoscape 2020a & Ecoscape 2020b). These have been broadly grouped based on the following three landform types:

- predominantly hillcrests/hillslopes: AiTw2, AiTw1, CcaAiTe, ChAiTe, ChAiTa, ChAiTw, ElAbTe, ElAptTe, ElAmTb, ElAmTe, ElGwTe
- stony plains: AoTl, AsTl
- predominantly drainage lines: ChAmTe, ChApyTt, EvApyCci.

Vegetation types are described in Table 7-6 and depicted in Figure 7-2.

Table 7-6: Vegetation types mapped within the Development Envelope

Vegetation type	Description	Extent within Development Envelope (ha)	% of Development Envelope
Predominantly hillslopes and crests			
AiTw1	*Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* hummock grassland.	601.4	13.5
AiTw2	*Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* and *T. longiceps* mid hummock grassland.	157.6	3.5
CcaAiTe	*Corymbia candida* subsp. *dipsodes, C. hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia inaequilatera, Grevillea wickhamii* subsp. *hispidula* and *Hakea chordophylla* tall, isolated shrubs over *Triodia epactia* low hummock grassland.	103.4	2.3
ChAiTe	*Corymbia hamersleyana* and Eucalyptus *leucophloia* subsp. *leucophloia* low woodland over *Acacia inaequilatera, A. bivenosa* and *Indigofera monophylla* low isolated shrubland over *Triodia epactia* low hummock grassland.	1,439.4	32.2
ChAiTa	*Corymbia hamersleyana* low isolated trees over *Acacia inaequilatera* tall, isolated shrubs over *Triodia angusta* and *T. wiseana* low hummock grassland.	81.3	1.8
ChAiTw	*Corymbia hamersleyana low isolated clumps of trees over Acacia inaequilatera, A. bivenosa mid open shrubland over Triodia wiseana* low hummock grassland.	67.9	1.5
ElAbTe	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia bivenosa, A. ptychophylla* and *A. monticola* mid shrubland over *Triodia brizoides, T. epactia* and *Cymbopogon ambiguus* mid hummock/tussock grassland.	891.8	20.1
ElAptTe	*Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* low woodland over *Acacia ptychophylla, A. inaequilatera* and *Indigofera* monophylla low isolated shrubland over *Triodia epactia, T. brizoides* low hummock grassland.	148.9	3.3

Vegetation type	Description	Extent within Development Envelope (ha)	% of Development Envelope
ElAmTb	*Eucalyptus leucophloia* subsp. *leucophloia* low woodland over *Acacia monticola* mid isolated clumps of shrubs over *Triodia brizoides* and *T. epactia* low hummock grassland.	37.8	0.9
ElAmTe	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia monticola, A. bivenosa* and *Grevillea wickhamii*. shrubland over *Triodia epactia, Eriachne lanata* mid hummock/tussock grassland.	25.5	0.6
ElGwTe	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated clumps over *Senna glutinosa* subsp. *glutinosa* and *Grevillea wickhamii*. tall open shrubland over *Triodia epactia* and *Eriachne mucronata* mid hummock grassland/ mid isolated clumps of tussock grasses.	63.8	1.4
Stony plains			
AoTl	*Acacia orthocarpa, A. monticola* and *A. bivenosa* low sparse shrubland over *Triodia longiceps* and *T. epactia* low hummock grassland.	37.7	0.8
AsTl	*Acacia synchronicia* mid isolated shrubs over *Triodia longiceps* and *Triodia wiseana* mid sparse hummock grassland.	72.9	1.6
Predominantly drainage lines			
ChAmTe	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia monticola, A. tumida* var. *pilbarensis,* and *Grevillea wickhamii*. tall open shrubland over *Triodia epactia and Eriachne lanata* low open hummock/ tussock grassland.	498.2	11.2
ChApyTt	*Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* and *Acacia tumida* var. *pilbarensis* tall shrubland over *Themeda triandra*, *Triodia longiceps* and *Chrysopogon fallax* tall tussock grassland/hummock grassland.	99.6	2.2

Vegetation type	Description	Extent within Development Envelope (ha)	% of Development Envelope
EvApyCci	*Eucalyptus victrix* and *Corymbia hamersleyana* mid open woodland over *Acacia pyrifolia*, *Acacia trachycarpa* and *Acacia tumida* var. *pilbarensis* tall shrubland over **Cenchrus ciliaris*, *Triodia longiceps* and *Cyperus vaginata* low tussock grassland/hummock grassland/sedgeland.	131.1	2.9
Cleared (not vegetated)		6.7	0.2
TOTAL		**4,465**	**100**

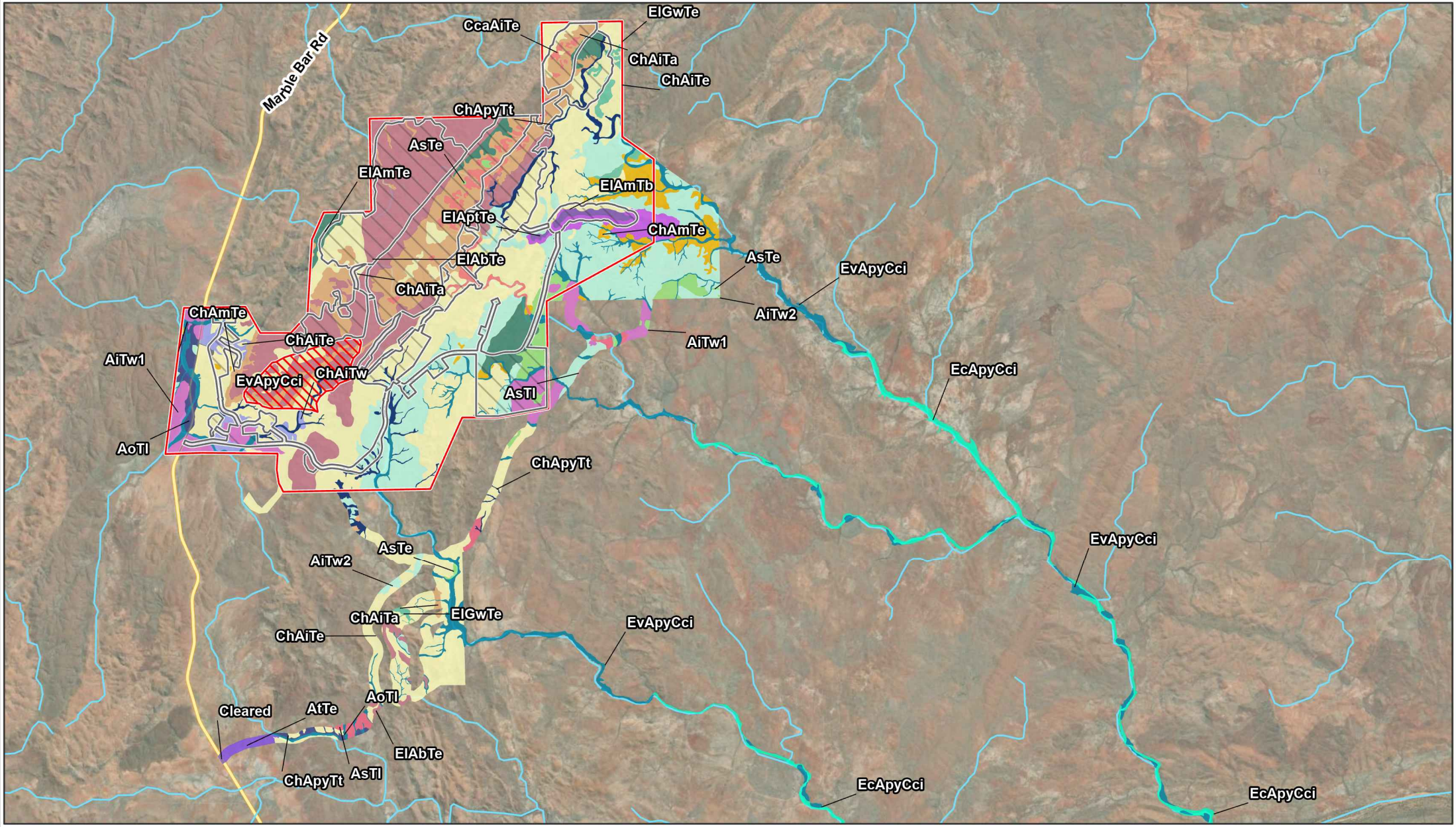

Figure 7-2: Vegetation types mapped within and adjacent to the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone

Vegetation Unit (Ecoscape 2020)

AiTw1
AiTw2
AoTl
AsTe
AsTl
AtTe
CcaAiTe
ChAiTa
ChAiTe
ChAiTw
ChAmTe
ChApyTt
EcApyCci
ElAmTe
ElAmTb
ElAbTe
ElAptTe
ElGwTe
EvApyCci
Cleared

0 0.75 1.5 3
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

N

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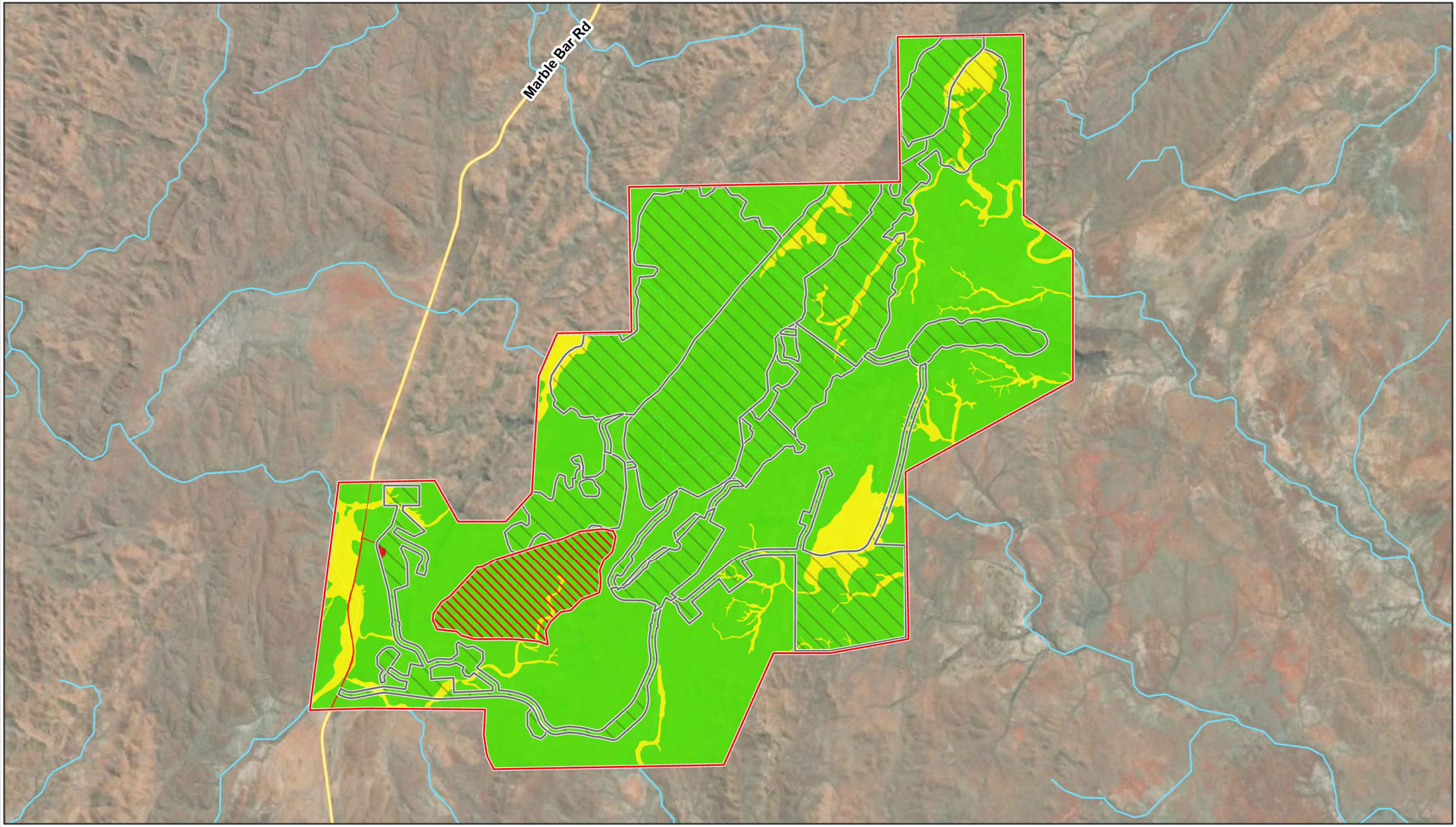

Figure 7-3: Vegetation condition mapped within and adjacent to the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone

Vegetation Condition

Cleared
Good
Excellent

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

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7.3.2.5 Conservation significant vegetation

None of the vegetation types mapped in the Development Envelope are considered to represent any current Western Australian listed or Commonwealth EPBC Act listed Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs), and none are known to occur in the vicinity of the Development Envelope.

Seven of the vegetation types comprise less than 2% of the Development Envelope (AoTl, AsTl, ChAiTa, ChAiTw, ElAmTb, ElAmTe and ElGwTe). This is an artefact of the Development Envelope boundary which is focussed on the resource within rocky ridge area and minimises potential disturbance to drainage lines. Although this may indicate some local significance within the Development Envelope, these vegetation types are not considered to be significant otherwise.

7.3.2.6 Potential groundwater dependent vegetation

Vegetation types associated with groundwater can be locally restricted in the landscape and are therefore described below as potentially significant vegetation.

One vegetation type (EvApyCci, 131.1 ha) located within the Development Envelope may represent groundwater dependent vegetation (GDV) due to the presence of *Eucalyptus victrix* (Figure 7-4). This species is a facultative phreatophyte, meaning that it is deep rooted and taps into groundwater opportunistically if available, but can also be supported by surface water inputs to the vadose (unsaturated) zone in certain situations and stand densities. Depth to groundwater in the vicinity of the EvApyCci vegetation unit is generally less than 10 m. Dependence on groundwater is considered likely where the depth to groundwater is less than 10 m, and unlikely where the depth to groundwater is more than 10 m to groundwater (Ecoscape 2020a).

It is noted that an additional vegetation type considered to represent a likely GDV (EcApyCci) was mapped outside of the Development Envelope, along the three creeklines which occur to the south (McPhee Creek, Branch of McPhee Creek and Lionel Creek) (Figure 7-4). This vegetation type supports *Eucalyptus camaldulensis, Atalaya hemiglauca, Melaleuca glomerata* and *Sesbania cannabina*. All areas where *E. camaldulensis* was recorded as a characteristic species were located in areas where the depth to groundwater was less than 10 m (Ecoscape 2020a) and this species is a facultative phreatophyte. Depth to groundwater is modelled to be between 2-10 m bgl in these areas and vegetation is considered potentially groundwater dependent (Ecoscape 2020a). The groundwater in these creeklines occurs within the creek alluvial aquifers, which are connected to the underlying fractured rock aquifers but also receive direct recharge from rainfall and surface flows, which regularly top up groundwater levels.

No surface water dependent vegetation has been identified in the Development Envelope (Ecoscape 2020a).

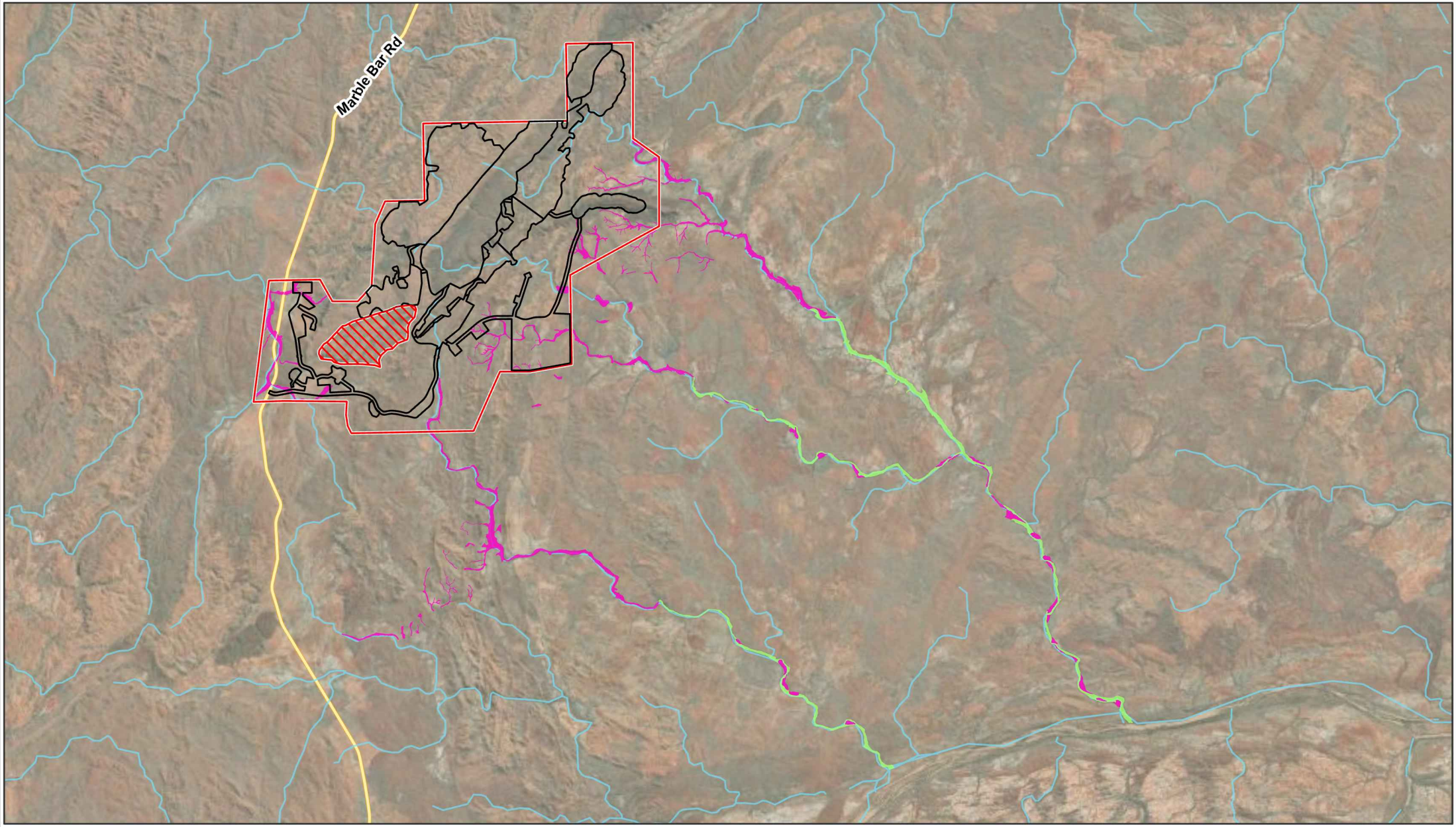

Figure 7-4: Potential groundwater dependent vegetation within and adjacent to the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone
Drainage lines

Groundwater Dependant Vegetation

EcApyCci
EvApyCci

0 1 2 4
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

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7.3.3 Flora

Ecoscape (2020a) recorded a total of 224 vascular flora in their survey area from 34 families and 97 genera. The most represented families were Fabaceae with 51 taxa, Poaceae with 42 taxa and Malvaceae with 24 taxa. The most represented genera were *Acacia* with 26 taxa, and *Ptilotus* and *Senna* each with nine taxa. The most frequently recorded taxa were *Triodia epactia*, *Indigofera monophylla* and *Corchorus parviflorus*.

7.3.3.1 Conservation significant flora

Conservation significant flora are species listed under the EPBC Act, the BC Act, or Priority species identified by DBCA as requiring further protection. No Threatened flora species listed under the EPBC Act or the BC Act have been recorded within the Development Envelope during the recent survey (Ecoscape 2020a) or from any previous surveys conducted.

Four Priority flora species have been recorded in the Development Envelope and are identified in Table 7-7. Three of the four species were recorded during the most recent survey, while one species, *Eragrostis crateriformis* (Priority 3) was recorded by previous survey effort (Woodman 2019a; Woodman 2014a; Woodman 2013; Woodman 2012). Despite extensive searches in previously known locations, *Eragrostis crateriformis* was not detected during 2020 (Ecoscape 2020a). This species is considered likely to have a scattered/sporadic distribution within the Development Envelope and responds strongly to seasonal rainfall events and may not always be present. This species although not detected during the 2020 survey, may be present in low numbers within the Development Envelope (Ecoscape 2020a).

One additional unconfirmed Priority flora species, *Goodenia nuda* (Priority 4), was recorded at one location in the Development Envelope in 2014 (Woodman 2014b). The species was not recorded during the most recent survey (Ecoscape 2020a). The historical record is unconfirmed. Woodman (2019a) indicates it is a possible mis-identification as the habitat it was recorded from is not its usual habitat (Ecoscape 2020a). *Goodenia nuda* is therefore not considered further in this assessment.

None of the flora taxa recorded from the survey area are considered to represent range extensions of any significance. Figure 7-5 depicts records of Priority flora in the Development Envelope.

Table 7-7: Conservation significant flora recorded within the Development Envelope and surrounding region and nearby projects

Species	Habitat	Vegetation type	No. of populations (individuals) in Development Envelope	Other previous records of species	
				Atlas of Living Australia records^	Records from nearby projects^^
Acacia aphanoclada Priority 1	Rocky spinifex (*Triodia* spp.) hills with scattered eucalypts and acacias. Occurs on Mosquito Creek sediments and on conglomerates.	ChAiTe	1 (1)	43 records from Chichester area in the Pilbara.	
Rostellularia adscendens var. *latifolia* Priority 3	Ironstone soils, near creeks and on rocky hills.	ChAiTe EvApyCci	3 (3)	36 records from the Ashburton and East Pilbara areas in the Pilbara, including 21 records within approximately 200 km of the Proposal. Five records occur within conservation estate*.	7 population records
Ptilotus mollis Priority 4	Rock piles, gorges, riverbeds and alluvial soils.	AiTw2 ChAiTe ChAmTe ChApyTt ElAptTe ElGwTe ElAbTe ElAmTb ElAmTe	283 (5,919)	34 records from Chichester, Hamersley, Roebourne and Rudal areas in Little Sandy Desert and Pilbara regions. 20 records occur within approximately 200 km of the Proposal. Three records occur within conservation estate*, namely Karijini National Park and Ex Meentheena Station nature reserve.	50 population records

Species	Habitat	Vegetation type	No. of populations (individuals) in Development Envelope	Other previous records of species	
				Atlas of Living Australia records^	Records from nearby projects^^
Eragrostis crateriformis Priority 3	Seasonally inundated habitats of high clay content including open or closed wet depressions, claypans and adjacent to creeks or riverbeds on lower lying areas surrounding the Main Range (Woodman 2013).	AiTw2 AsTl CcaAiTe ChAiTe ChAiTw ChApyTt EvApyCci	70 (1,348)	47 records within Western Australia of which 36 are within approximately 200 km of the Proposal. Two records occur within conservation estate*, namely Ex Meentheena Station Nature Reserve and the Paruku Indigenous Protected Area. There are also an additional four records within the Northern Territory.	83 location records, including at least 15,015 individuals.

^Data for individual species was collected by downloading records from Atlas of Living Australia using the R package 'galah' (Stevenson et al. 2022). Spatially inaccurate records as defined by Atlas of Living Australia were removed from the dataset (ALA 2022).

^^Location records from other mining projects within 200 km of the Proposal (listed in Section 7.4.3). These records are not proposed to be impacted.

*The true location of conservation significant species is not available for protection purposes. The location of data points is therefore an estimated location, however given the size of the conservation estates it is considered highly likely that the species would occur.

7.3.3.2 Introduced flora

A total of sixteen introduced flora species (weeds) have been recorded in the Development Envelope (Ecoscape 2020a and Woodman 2019a), including:

- *Calotropis procera* (Rubber bush)
- *Aerva javanica* (Kapok bush)
- *Cenchrus ciliaris* (Buffel grass)
- *Cenchrus setiger* (Birdwood grass)
- *Cynodon dactylon* (Couch)
- *Echinochloa colona* (Awnless Barnyard Grass)
- *Malvastrum americanum* (Spiked Malvastrum)
- *Argemone ochroleuca* (Mexican Poppy)
- *Chloris barbata* (Purpletop Chloris, Feathertop Rhodes Grass)
- *Citrullus amarus* (Pie Melon)
- *Euphorbia hirta* (Asthma Plant)
- *Flaveria trinervia* (Speedy Weed)
- *Portulaca pilosa* (Djanggara)
- *Setaria verticillata* (Whorled Pigeon Grass)
- *Sonchus oleraceus* (Common Sowthistle)
- *Vachellia farnesiana* (Mimosa Bush).

The most commonly recorded species was Buffel grass. The presence of Buffel grass influenced vegetation condition along drainage lines. One introduced flora species, Rubber bush is a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007* (BAM Act 2007) and was recorded in one location in the Development Envelope. None of the species recorded are Weeds of National Significance (WoNS) on the Western Australian Organism List (WAOL) database. Locations of introduced flora species (weeds) are shown on Figure 7-6.

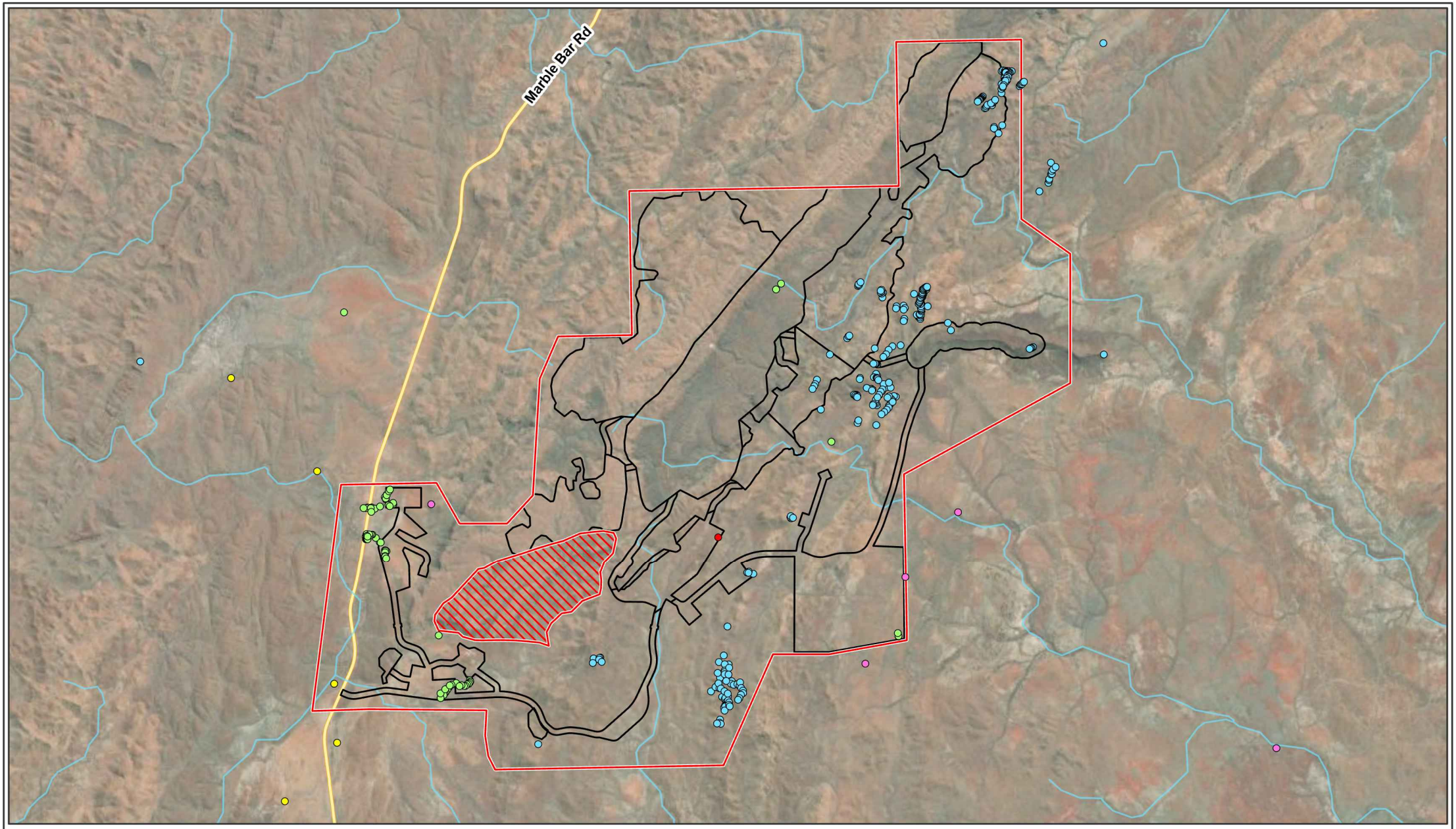

Figure 7-5: Priority flora recorded in the Development Envelope

Development Envelope

Conceptual Footprint

Significant Fauna Exclusion Zone

Conservation Significant Flora (Woodman 2019a and Ecoscape 2020)

- *Acacia aphanoclada* (P1)
- *Eragrostis crateriformis* (P3)
- *Rostellularia adscendens* var. *latifolia* (P3)
- *Goodenia nuda* (P4)
- *Ptilotus mollis* (P4)

0 0.5 1 2

Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

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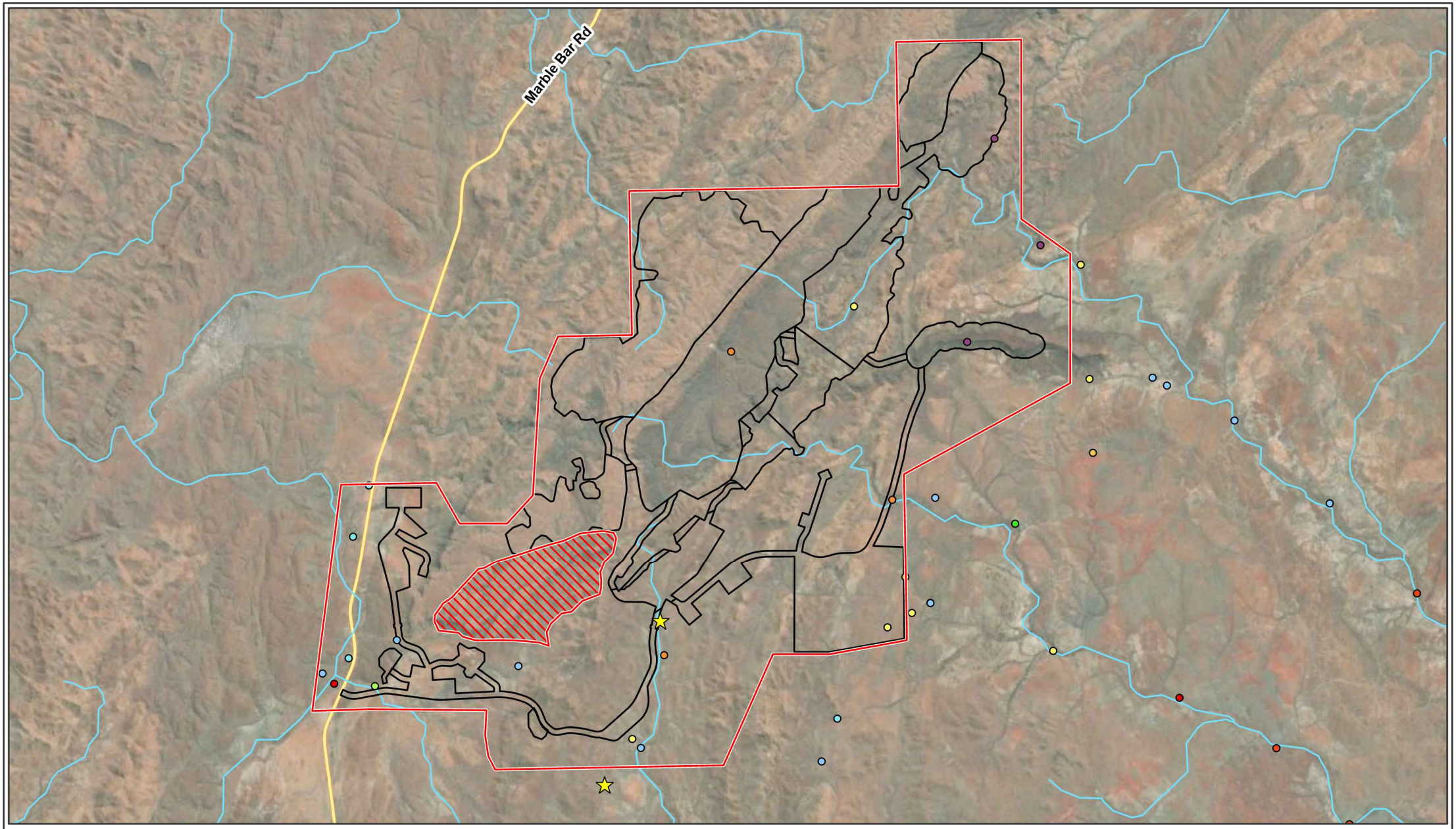

Figure 7-6: Introduced flora species (weeds) recorded within and adjacent to the Development Envelope

Development Envelope
Significant Fauna Exclusion Zone
Conceptual Footprint

TaxonName

- Aerva javanica
- Aerva javanica*
- Argemone ochroleuca*
- Calotropis procera
- Cenchrus ciliaris
- Cenchrus ciliaris*
- Cenchrus setiger
- Cenchrus setiger*
- Chloris barbata*
- Citrullus lanatus*
- Cynodon dactylon
- Cynodon dactylon*
- Echinochloa colona
- Echinochloa colona*
- Euphorbia hirta*
- Flaveria trinervia*
- Malvastrum americanum
- Malvastrum americanum*
- Portulaca pilosa*
- Setaria verticillata*
- Sonchus oleraceus*
- Vachellia farnesiana*

0 0.5 1 2
Kilometres

Datum/Projection:
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7.4 Potential environmental impacts

7.4.1 Direct impacts

Potential direct impacts of the Proposal to flora and vegetation relate to clearing of land and have been identified as:

- loss of native vegetation (including riparian vegetation)
- loss of individuals of Priority flora species.

7.4.1.1 Loss of native vegetation (including riparian vegetation)

This section presents the indicative loss of vegetation based on the Conceptual Footprint; however, there is some flexibility to alter the final location of Proposal elements within the Development Envelope.

The Proposal will clear up to 1,913 ha (the 'Conceptual Footprint') of native vegetation within the 4,465 ha Development Envelope across all 16 of the mapped vegetation types (Table 7-8) and ranging in condition (Table 7-9). Based on the Conceptual Footprint, this will include the clearing of:

- Approximately 1,783 ha of vegetation in Excellent condition
- Approximately 128.9 ha of vegetation in Good condition.

This clearing is inclusive of approximately 24 ha of vegetation type EvApyCci, riparian vegetation (considered a potential GDV).

Table 7-8: Indicative clearing of vegetation types based on the Conceptual Footprint

Vegetation type	Total extent mapped by Ecoscape 2020 survey (ha)	Extent within Development Envelope (ha)	Extent within Conceptual Footprint (ha)	Approximate % to be cleared from the Development Envelope	Approximate % remaining within the Development Envelope after proposed clearing	Approximate % of total mapped extent to be cleared
Predominantly hillslopes and crests						
AiTw1	829.5	601.4	109.4	18.2	81.8	13.2
AiTw2	798.7	157.6	65.2	41.4	58.6	8.2
CcaAiTe	105.2	103.4	90.7	87.7	12.3	86.2
ChAiTe	2,696.3	1,439.4	447.5	31.1	68.9	16.6
ChAiTa	616.3	81.3	6.2	7.6	92.4	1.0
ChAiTw	77.9	67.9	20.1	29.6	70.4	25.8
ElAbTe	1,769.3	891.8	550.9	61.8	38.2	31.1
ElAptTe	150.1	148.9	77.5	52.0	48.0	51.6
ElAmTb	123.1	37.8	6.8	18.0	82.0	5.5
ElAmTe	73.1	25.5	21.3	83.5	16.5	29.1
ElGwTe	77.5	63.8	22.3	34.9	65.1	28.8
Stony plains						
AoTl	53.2	37.7	0.0	0.0	100.0	0
AsTl	123.0	72.9	37.5	51.4	48.6	30.5
Predominantly drainage lines						
ChAmTe	630.1	498.2	393.1	78.9	21.1	62.4
ChApyTt	134.9	99.6	39.4	39.6	60.4	29.2
EvApyCci (potential GDV)	544.1	131.1	24.0	18.3	81.7	4.4

Vegetation type	Total extent mapped by Ecoscape 2020 survey (ha)	Extent within Development Envelope (ha)	Extent within Conceptual Footprint (ha)	Approximate % to be cleared from the Development Envelope	Approximate % remaining within the Development Envelope after proposed clearing	Approximate % of total mapped extent to be cleared
Cleared		6.7	1.1			
TOTAL	**8,802.3**	**4,465**	**1,913**			

Table 7-9: Condition of vegetation within the Conceptual Footprint

Vegetation condition	Extent in Development Envelope (ha)	Extent in Conceptual Footprint (ha)
Excellent	4,081.6	1,783
Good	376.6	128.9
Cleared (not vegetated)	6.7	1.1
TOTAL	**4,465**	**1,913**

7.4.1.2 Loss of individuals of Priority flora species

The Development Envelope contains four Priority flora species. The Conceptual Footprint avoids clearing one of these species, *Rostellularia* adscendens var. *latifolia*. Implementation of the Proposal will likely result in clearing of individuals from two Priority flora species: *Eragrostis crateriformis* (P3) and *Ptilotus mollis* (P4). It is noted that one Priority 1 flora species, *Acacia aphanoclada*, is also located within the Conceptual Footprint, however the Proponent commits to retaining the single recorded individual within the Development Envelope. The indicative loss of Priority flora species based on the Conceptual Footprint are identified in Table 7-10.

Table 7-10: Indicative loss of Priority flora species based on the Conceptual Footprint

Species	No. of populations (individuals) in the Development Envelope	No. of populations (individuals) in the Conceptual Footprint	Approximate % loss of individuals known within Development Envelope	Number of known populations in the State that will not be impacted by the Proposal*
Acacia aphanoclada *Priority 1*	1 (1)	1(1)	0 (the Proponent commits to retaining this individual)	42 – One known record occurs within the Development Envelope.
Rostellularia adscendens var. *latifolia* Priority 3	3 (3)	0	0	36 including five records in conservation estate**
Eragrostis crateriformis Priority 3	70 (1,348)	31 (815)	60.5	34 including three records in conservation estate**
Ptilotus mollis Priority 4	283 (5,919)	58 (842)	14.2	47 including two records in conservation estate**

*Data for individual species was collected by downloading records from Atlas of Living Australia using the R package 'galah' (Stevenson et al. 2022). Spatially inaccurate records as defined by Atlas of Living Australia were removed from the dataset (ALA 2022).

**The true location of conservation significant species is not available for protection purposes. The location of data points is therefore an estimated location, however given the size of the conservation estates it is considered highly likely that the species would occur.

7.4.2 Indirect impacts

Potential indirect impacts of the Proposal to flora and vegetation have been identified as:

- Introduction or spread of weeds
- Degradation or alteration of vegetation as a result of altered surface water flows due to construction of infrastructure
- Impacts to groundwater dependent vegetation as a result of groundwater drawdown from mine dewatering
- Impacts to riparian vegetation as a result of surplus water discharge to surface water systems
- Degradation of vegetation through dust deposition.

7.4.2.1 Introduction or spread of weeds

Clearing, vehicle and machinery movements have the potential to increase the spread and/or introduce weed species. Weeds are often able to rapidly invade locations due to disturbance, land clearing and/or altered hydrological regimes. Sixteen weed species have been recorded within the Development Envelope. One species, Rubber bush (*Calotropis procera*), is a Declared Pest, and none of the species identified are listed as WONS species (Ecoscape 2020a). *Calotropis procera* was recorded amongst an outcropping in the centre of the Development Envelope (Figure 7-5) and is located approximately 24 m from the Conceptual Footprint.

Buffel Grass (*Cenchrus ciliaris*), introduced as a pastoral species, has significantly affected vegetation condition, mainly in riparian vegetation types. The presence and impact of this species is not a result of mining activities, and mining is unlikely to significantly increase the impact. Other identified introduced species currently occur sporadically and are having little effect on vegetation condition (with the exception of the single location of *Calotropis procera*).

7.4.2.2 Degradation or alteration of vegetation as a result of altered surface water flows around infrastructure

Mine pits and infrastructure have the potential to reduce the catchment area of creeklines. The creek catchment reductions from mining infrastructure are around 10% in McPhee Creek, Branch of McPhee Creek and Sandy Creek and some catchment flows will be reinstated at closure (Section 6.5.1.3). There is no loss of catchment in Lionel Creek and minimal loss in Spinaway Creek. These catchment losses would have a corresponding reduction in runoff and flood depth and volumes immediately downstream of the infrastructure. Given the Pilbara rainfall patterns where most rainfall is episodic with generally short periods of runoff and creek flow, a small reduction in catchment and peak flows is unlikely to change the hydrological regime to the extent that it affects any environmental values.

7.4.2.3 Impacts to groundwater dependent vegetation as a result of groundwater drawdown from mine dewatering

The risk of impact to potential GDV increases with drawdown (both the quantum and rate of drawdown) and decreases with pre-mining depth to groundwater (as vegetation is more likely to access shallow watertables). Simple risk mapping has been completed based on total drawdown and the pre-mining depth to groundwater within the areas of potential GDV mapped by Ecoscape (2020a, Figure 6-24). Ecoscape (2020a) notes that where the depth to groundwater is more than 10 m, vegetation is only likely to access groundwater opportunistically.

The rate of drawdown will also affect the likelihood and severity of potential impacts to GDV (Froend and Loomes 2004). The rate of drawdown in areas beyond the McPhee Creek ridge is slow as there is low transmissivity beyond the orebody aquifers.

There is 51.4 ha (47.5 ha within the Development Envelope and 3.9 ha outside) of potential GDV that is within areas with shallow watertables (<10 m bgl) where drawdown in the underlying fractured rock aquifer of greater than 2 m is predicted. These areas are highlighted in yellow in Table 6-14. However, these areas are associated with creekline vegetation and likely access alluvial aquifers. Vegetation health in these areas is unlikely to be significantly affected as the maximum rate of drawdown in the underlying fractured rock aquifer is 6 cm/year and at these rates (if they did occur) vegetation would be likely to be able to adapt at this rate. However, the alluvial aquifers are topped up by direct recharge from rainfall and creek flows after every major rainfall event. This localised recharge would naturally mitigate any change in water levels in the alluvial aquifer that could occur due to slow leakage into the underlying fractured rock aquifer. This localised recharge to alluvial aquifers is not accounted for in the groundwater modelling by GHD (2021a).

The critical issue for phreatophytic vegetation is the depth of the water table (and its associated vadose zone) below the ground surface, and its accessibility by roots. If abstraction lowers the water table beyond the depth from which roots can obtain water, those elements of the vegetation community with full dependence on groundwater will die (Nevill et al. 2010). In this instance, the Proposal is predicted to result in a very slow rate of drawdown in the underlying aquifers (<6 cm/yr). When combined with the continued regular recharge of the alluvial systems where the potential GDV occurs, the risk of impacts to the vegetation structure of the GDV as a result of dewatering is expected to be low. Minor changes to vegetation health, (i.e. non-permanent

reduction in plant health, usually a straight reduction in canopy cover) may still occur within potential GDV areas inside the Development Envelope, however this is anticipated to be temporary with the slow drawdown rate and regular recharge allowing time for the potential GDV to adapt. Impacts will be managed through the implementation of the Water Management Plan (Appendix B).

Beyond the Development Envelope, the rates of drawdown in potential GDV areas are modelled to be less than 1-2 cm/yr and therefore there is negligible potential for change in these areas.

7.4.2.4 Impacts to riparian vegetation as a result of surplus water discharge to surface water systems

Dewatering stages of the Proposal will result in the discharge of surplus water into three creeklines, including McPhee Creek, Branch of McPhee Creek and Lionel Creek, all of which are tributaries of the Nullagine River. The release of this water into the environmental has the potential to alter the hydrological regimes within the creek catchments. The maximum wetting fronts for each of the creeks are:

- 15 km in McPhee Creek
- 7 km in Branch of McPhee Creek
- 12 km in Lionel Creek

Controlled discharge to these creeks will not be continuous and peak discharge will only occur early in mine life.

Long term discharge has the potential to create mounding in the alluvial aquifer which could cause waterlogging for deep rooted vegetation and an associated change to vegetation types. This effect will be avoided for the Proposal due to limited years of high rate discharge and by varying the rate and location of discharge across three creeks.

7.4.2.5 Degradation of vegetation through dust deposition

Dust will be generated during construction and operation of the Proposal. An air quality assessment determined that dust deposition is mostly limited to the Conceptual Footprint of the Proposal (ETA 2021). As such, the impact to vegetation due to dust emissions is expected to be localised to vegetation in the immediate vicinity of disturbance.

7.4.3 Cumulative impacts

The Proposal will contribute to the following cumulative impacts at a regional scale:

- Loss of native vegetation due to clearing
- Loss of individuals of Priority flora due to clearing.

Cumulative impacts have been considered within 200 km of the Proposal, based on an assessment of publicly available information on existing, proposed and undeveloped major mine projects (Figure 7-7). The projects that have been considered in relation to cumulative impacts are listed in in Table 7-11.

Table 7-11: Mining projects within 200 km of the Proposal

Proponent	Project name
Atlas Iron Pty Ltd	Sanjiv Ridge Stage 1 and Stage 2
Atlas Iron Pty Ltd	Pardoo Iron Ore Mine and Direct Shipping from Port Hedland
Atlas Iron Pty Ltd	Miralga Creek Direct Shipping Ore Project
Atlas Iron Pty Ltd	Turner River Hub Project

Proponent	Project name
Australian Aboriginal Mining Corporation	Extension Mining Project
BC Pilbara Iron Ore	Iron Valley Below Water Table Project
BHP Billiton Iron Ore	Eastern Ridge Revised Proposal
BHP Billiton Iron Ore	Goldsworthy Iron Ore Mines Extension Project
BHP Billiton Iron Ore	Jimblebar Optimisation Project
BHP Billiton Iron Ore	Mining Area C
BHP Billiton Iron Ore	Orebody 18 Iron Ore Mine
BHP Billiton Iron Ore	Orebody 31 Iron Ore Mine
BHP Billiton Iron Ore	Orebody 32 Above Water Table Iron Ore Mine Project
BHP Billiton Iron Ore	Orebody 35 Iron Ore Mine
Brockman Mining Limited	Marillana Iron Ore Project
Birla (Nifty)	Gas Pipeline to Nifty Copper Operations Great Sandy Desert
Cameco Australia	Kintyre Uranium Project
Consolidated Minerals	Woodie Continued Operations Project
FerrAus	Ferraus Pilbara Project
Fortescue Metals Group	Christmas Creek Iron Ore Mine Expansion
Fortescue Metals Group	Cloudbreak (Life of Mine and Expansion)
Fortescue Metals Group	North Star Hermatite Project
Fortescue Metals Group	Solomon Iron Ore Project
Fortescue Metals Group	Nyidinghu Iron Ore Project
Hamersley Iron	Yandicoogina Iron Ore Project (Pocket and Billiard South Project; Expansion to include Junction South West and Oxbow Deposits)
Moly Metals Australia	Spinifex Ridge Molybdenum Project
Mount Bruce Mining	Koodaideri Iron Ore Mine and Infrastructure Project
Newcrest Mining	Telfer Project, Project Power Supply and infrastructure Corridor
Reward Minerals Ltd	Lake Disappointment Potash Project
Rio Tinto Iron Ore	Baby Hope Proposal
Robe River Mining Co. Pty Ltd	West Angelas Iron Ore Project (Original and Expansion)
Roy Hill Iron Ore	Roy Hill Iron Ore Mine (Original and Revised)
Venturex Resources	Sulphur Springs Copper-Zinc Project

Each of the above projects were assessed for cumulative impacts associated with the current Proposal, with different projects relevant to different impacts. Key assumptions were made in the assessment of the cumulative impact assessment for flora and vegetation. These assumptions are:

- Cumulative impacts have been assessed based on information available in the public domain, and does not include the impacts associated with all third-party operations in the Pilbara

- Data available in the public domain has been assumed to be reliable and accurate
- The majority of records are based on locations of a species, as opposed to number of individuals. These locations may support small or large populations.
- Cumulative impacts have been assessed through projects that have been referred to the EPA and does not consider future proposals that have not yet been referred.

Impacts from pastoral and/or grazing activities have not been quantified and are therefore not able to be included in cumulative impacts calculations.

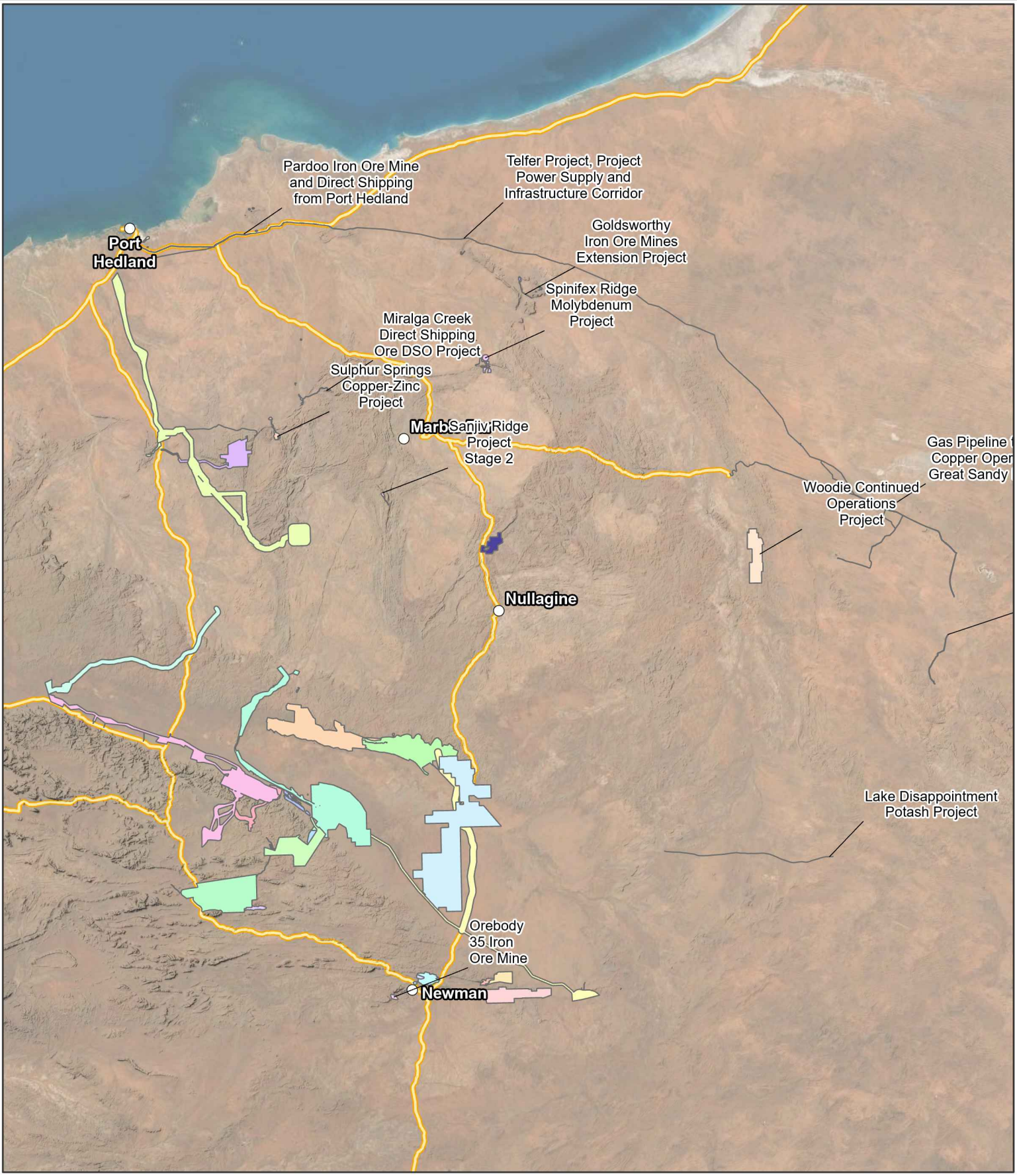

Figure 7-7: Projects within 200 km of Proposal used to assess cumulative impacts

- Baby Hope Proposal
- Christmas Creek Iron Ore Mine Expansion
- Cloudbreak Life of Mine, Pilbara
- Eastern Ridge Revised Proposal
- Extension Mining Project
- Ferraus Pilbara Project
- Gas Pipeline to Nifty Copper Operations Great Sandy Desert
- Goldsworthy Iron Ore Mines Extension Project
- Iron Valley Below Water Table Project
- Jimblebar Optimisation Project
- Kintyre Uranium Project
- Koodaideri Iron Ore Mine and Infrastructure Project
- Lake Disappointment Potash Project
- Marillana Iron Ore Project
- Mining Area C - Southern Flank
- Miralga Creek Direct Shipping Ore DSO Project
- North Star Hematite Project
- Nyidinghu Iron Ore Project
- Orebody 18 Iron Ore Mine
- Orebody 31 Iron Ore Mine
- Orebody 32 Above Water Table Iron Ore Mine Project
- Orebody 35 Iron Ore Mine
- Pardoo Iron Ore Mine and Direct Shipping from Port Hedland
- Roy Hill Iron Ore Mine - Revised Propoal
- Sanjiv Ridge Project Stage 2
- Solomon Iron Ore Project - Sustaining Production
- Spinifex Ridge Molybdenum Project
- Sulphur Springs Copper-Zinc Project
- Telfer Project, Project Power Supply and Infrastructure Corridor
- Turner River Hub Project linear infrastructure stretches approximately 200km north-south from Port Hedland to Mount Webber Pilbara Region.
- West Angelas Iron Ore Project Deposits C D and G
- West Angelas Revised Proposal
- Woodie Continued Operations Project
- Yandicoogina Iron Ore Project - Expansion to include Junction South West and Oxbow Deposits

Towns (Statewide)

Road Hierarchy

Distributor Road

Access Road

0 20 40 80

Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51

Project: 15064-DD Date: 12/04/2022

N

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7.4.3.1 Cumulative loss of native vegetation due to clearing

Clearing for the Proposal will result in the loss of native vegetation from the Development Envelope. Detailed vegetation mapping has been completed for the Development Envelope and surrounds; however, it is not available for the broader Pilbara region. Therefore, the assessment of potential cumulative impacts to vegetation require broader mapping available across the region. Broad-scale vegetation mapping has been used to assess the cumulative loss of vegetation and flora from existing and reasonably foreseeable future projects in the region.

The Proposal will result in the clearing of up to 1,913 ha of native vegetation in addition to the potential clearing of approximately 159,000 ha from other projects within 200 km of the Proposal. The cumulative effect of native vegetation clearing is presented in Table 7-12. The current (2018) extent of vegetation within the Pilbara region is 17,731,765 ha (GoWA 2019). Based on the predicted impacts, clearing for the Proposal will contribute a further 0.01% to vegetation clearing within the bioregion.

Table 7-12: Cumulative impacts to native vegetation within a 200 km radius of the Proposal

	Extent proposed to be cleared (ha)		
	This Proposal	**Nearby projects**	**Cumulative extent of proposed clearing**
Proposed extent of native vegetation disturbance	1,913	159,000	160,913

Cumulative impacts on vegetation associations are shown in Table 7-13. The projects included in the assessment of cumulative impacts are those that are indicated to have known impacts on one or both of the vegetation associations that occur within the Proposal Development Envelope. It is noted that the occurrence or relative disturbance to each vegetation association are not presented in publicly available impact assessment documentation for all projects. As such, estimates of the vegetation association occurrence within each project was estimated by calculating the total area of each vegetation association within the development envelopes of each project. Given this approach, the estimates are conservatively considering clearing occurring across the entire development envelope, as opposed to the disturbance footprints of each project.

Table 7-13: Cumulative impacts on vegetation associations within a 200 km radius of the Proposal

Vegetation association (unit)	**Pre-European extent (ha)**	**Current extent remaining within Pilbara bioregion (ha)**	**% of pre-European extent remaining**	**Approx. clearing from this Proposal (ha; % of current extent)**	**Clearing from nearby projects***	**Cumulative clearing (ha; % of current extent)**
George Ranges 171	271,036.9	269,728.3	99.5	1,322.5 (0.5%)	718	2,040.5 (0.76%)
Abydos Plain - Chichester 173	622,162	618,397.6	99.4	590.2 (0.1%)	3959	4,549.2 (0.74%)

*Areas proposed to be cleared for each vegetation association are based on the approved clearing limits or conservatively on the extent of the vegetation association in the entirety of the development envelope. This is therefore a conservative estimate of the clearing of these vegetation associations.

The National Objectives and Targets for Biodiversity Conservation includes a target to avoid clearance of existing vegetation with a pre-European extent of below 30% (Commonwealth of Australia 2001). Implementation of the Proposal and cumulative impacts from reasonably foreseeable projects, indicate that at least 98% or more of the pre-European extent of each of these associations will remain across the Pilbara Bioregion.

Cumulative impacts on land systems within a 200 km radius of the Proposal are detailed in Table 7-14. The projects listed are those that have known impacts on at least one of the four land systems present within the Development Envelope of the Proposal. It is noted that the occurrence or relative disturbance to each land system are not presented in publicly available impact assessment documentation for all projects. As such, estimates of the land system occurrence within each project was estimated by calculating the total area of each land system within the development envelopes of each project. Given this approach, the estimates are conservatively considering clearing occurring across the entire development envelope as opposed to the disturbance footprints of each project.

Table 7-14: Cumulative impacts on land systems within a 200 km radius of the Proposed Action

Land System	Current extent in Chichester subregion (ha)	Approx. clearing from this Proposal (ha; % of current extent)	Clearing from nearby projects*	Cumulative clearing (ha; % of current extent)
Capricorn	482,779	1408.8 (0.29%)	16,458	17,866.5 (3.7%)
Robe	25,182	75.6 (0.3%)	7,002	7,077.23 (28.1%)
Rocklea	2,123,354	345.3 (0.02%)	7,282	7,626.83 (0.36%)
Taylor	11,046	83.0 (0.75%)	-	83.0 (0.75%)

*Areas proposed to be cleared for each vegetation association are based on the approved clearing limits or conservatively on the extent of the land system in the entirety of the development envelope. This is therefore a conservative estimate of the clearing of these land systems.

The greatest cumulative impact on land systems associated with the Proposal is the loss of approximately 28% of the Robe land system within the Chichester subregion. It should be noted that this loss is highly conservative, given that calculations were based on the approximate extent of the land system within the entire development envelope of each project, rather than the disturbance footprint.

7.4.3.2 Cumulative loss of individuals of Priority flora due to clearing

Of the four Priority flora species present within the Development Envelope, three will be impacted by other nearby projects, as summarised in Table 7-15. The projects listed are those that have known impacts on the same Priority Flora species as the Proposal.

Table 7-15: Cumulative impacts on Priority Flora species within a 200 km radius of the Proposed Action

Flora species	Project	Number of known records (and individuals) potentially disturbed	Number of known records (and individuals) expected to be retained	Total cumulative loss of population records	Number of known records (and individuals) likely to be retained
Acacia aphanoclada (Priority 1)	Proposal	0 (0)	1 (1)	0	One population of one individual
Rostellularia adscendens var. *latifolia* (Priority 3)	Proposal	0 (0)	3 (3)	69 populations	10 population records, with an addition five within conservation estate
	FMG Christmas Creek	58			
	Atlas Sanjiv Ridge	4			
	Brockman Mining Marillana Iron Ore		7		
	FMG North Star Hematite	6 (84)			
	Hamersley Iron Yandicoogina Iron Ore Project	1			
Ptilotus mollis (Priority 4)	Proposal	58 (842)	225 (5077)	59 populations	275 population records with at least 5077 known individuals, with an additional three population records within conservation estate
	BC Iron Valley		20		
	BHP Marillana Creek (Yandi)		10		
	Venturex Resources Sulphur Springs Copper-Zinc Project	1 (1)			
	FMG North Star Magnetite		20		
	Proposal	31 (815)	39 (533)	42 populations	122 population records with at
	BHP Eastern Ridge	1 (10)			

Flora species	Project	Number of known records (and individuals) potentially disturbed	Number of known records (and individuals) expected to be retained	Total cumulative loss of population records	Number of known records (and individuals) likely to be retained
Eragrostis crateriformis (Priority 3)	Atlas Pardoo Iron Ore	2	1		least 15,548 known individuals, with an additional two population records within conservation estate
	Atlas Miralga Creek		17 (2976)		
	Roy Hill	8 (648)	65 (12,039)		

7.5 Mitigation

During the design of the Proposal the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to reduce the potential impacts of the Proposal to flora and vegetation. A summary of mitigation measures applied to address the key potential impacts on flora and vegetation is provided in Table 7-16.

Table 7-16: Application of mitigation hierarchy for flora and vegetation

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual Impact
Direct impact: loss of native vegetation	• The Proposal has been designed to reduce the extent of clearing required. • The Proponent will ensure clearing only occurs in approved ground disturbance areas (in accordance with a Ground Disturbance Permit) and will avoid any clearing occurring outside of the Development Envelope.	• Clearing of no more than 1,913 ha within a Development Envelope of 4,465 ha. • Vegetation clearing areas will be clearly demarcated in the field, in accordance with the Proponent's Ground Disturbance Permit Procedure, and no clearing will occur outside the approved clearing areas.	• Topsoil will be recovered and stockpiled to a maximum height of 2 m to preserve the soil physical/chemical properties and seed bank. • Stockpiled topsoil will be signposted to prevent accidental use or degradation of soil resources. • Topsoil will be progressively re-spread over temporary construction areas or utilised for future rehabilitation. • Rehabilitation will occur with vegetation comprised of native species of local provenance in accordance with the Mine Closure Plan (MCP; Appendix A).	• Clearing of up to 1,913 ha of native vegetation in good to excellent condition, including approximately 24 ha of riparian vegetation.
Direct impact: loss of Priority flora species	• The Conceptual Footprint avoids direct impacts to *Rostellularia adscendens* var. *latifolia* (P3) as far as practicable. • The known *Acacia aphanoclada* individual present within the Conceptual Footprint will be avoided.	• The Conceptual Footprint minimises impacts to Priority flora species as far as practicable.	• As above	• Loss of approximately 60.5% of *Eragrostis crateriformis* and 14.2% of *Ptilotus mollis* individuals from the Development Envelope.

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual Impact
	• The Proponent will ensure clearing only occurs in approved ground disturbance areas and no clearing will occur outside of the Development Envelope.			
Indirect impact: introduction or spread of weeds	• The introduction of new weed species and spread of existing weed species will be avoided through the implementation of hygiene procedures and weed management measures, including the inspections of mobile plant/equipment arriving and departing from the Proposal.	• Weed control will be undertaken, including targeted control of Rubber Bush (a Declared Pest). • Topsoil from weed risk areas will be separated from areas of low weed risk to limit spread throughout the Development Envelope.	• The MCP will detail specific weed management measures in rehabilitation areas	• The introduction or spread of weeds will be avoided and managed through the implementation of hygiene procedures and weed management measures.
Indirect impact: degradation or alternation of vegetation as a result of altered hydrological regimes	• Avoidance of mine dewatering and surface water discharge is not possible for this Proposal • Avoidance of interruption to surface water runoff is not possible	• Total volume of dewatering cannot be minimised. However, the Proponent is investigating an early commencement of dewatering (subject to approvals) to minimise peak dewatering rates. • Discharge rates will be managed between creeks to minimise impacts to pools and	• Waste dumps will be rehabilitated at closure to ensure they are stable and revegetated.	• Impacts to vegetation as a result of altered hydrological regimes will be managed through the implementation of the WMP (Appendix B).

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual Impact
		long-term mounding in alluvial aquifers • Discharge locations will be constructed with scour and erosion protection • Only water that is surplus to operational requirements will be discharged • Surface water management during operations and closure will be designed to reduce adverse impacts on the natural function and environmental value of watercourses, water quality and sheet flow downstream of the mine area • The Water Management Plan (WMP; Appendix B) will be implemented.		
Indirect impact: degradation of vegetation through dust deposition	• Complete avoidance of dust is not possible. However, vegetation clearing and earthworks will be avoided during high winds (>40 km/hr) where possible.	• Standard dust management measures will be utilised to minimise dust emissions and subsequent deposition on retained native vegetation in proximity to disturbance. • The Proponent's standard dust management procedures will be implemented throughout the life of the Proposal, including the following measures: • Implementation of speed limits on unsealed roads	• Progressive rehabilitation will be undertaken as areas become available • Topsoil stockpiles will not exceed 2 m in height • Traffic speed limits will be reduced on unsealed roads.	• Standard dust management measures and the Proponent's dust management procedures will be implemented to minimise impacts to vegetation. Given the naturally dusty environment of the Pilbara, a

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual Impact
		• Water carts will be utilised to limit dust generation from exposed surfaces • Blast plans will consider meteorological conditions to control the generation and dispersal of dust.		small and localised increase in dust deposition is not expected to significantly impact vegetation.

7.6 Assessment and significance of residual impact

7.6.1 Direct impacts

7.6.1.1 Loss of native vegetation (including riparian vegetation)

The Proposal will result in the clearing of up to 1,913 ha of native vegetation in predominantly Excellent condition (approximately 1,783 ha). Vegetation to be cleared within the Development Envelope represents two vegetation associations (171 and 173). Less than 1% of the total current pre-European extent of these vegetation associations is represented within the Development Envelope (Figure 7-2). However, as the Proposal is located within the Pilbara bioregion, the cumulative clearing is considered a significant impact and environmental offsets are therefore proposed (Section 13).

Based on the Conceptual Footprint, approximately 24 ha of riparian vegetation (EvApyCci) will be cleared, representing 18.3% of the extent mapped within the Development Envelope. Approximately 107 ha will remain within the Development Envelope. This loss is not considered significant given that this vegetation is common along creeklines both within the Development Envelope and beyond. However, the 24 ha of riparian vegetation is included within the 1,913 ha of vegetation in predominately Excellent condition and will therefore be offset.

No conservation significant vegetation communities (TECs or PECs) have been recorded within the Development Envelope.

Based on the Conceptual Footprint, clearing for the Proposal will result in removal of greater than 50% of the following six vegetation types from the Development Envelope: CcaAiTe, ElAbTe, ElAptTe, ElAmTe, AsTl and ChAmTe (Table 7-8). Detailed vegetation mapping has been completed for approximately 4,351.17 ha outside of the Development Envelope and the extent of these six vegetation types outside of the Development Envelope is shown in Table 7-17.

As shown in Table 7-17, 877.5 ha of vegetation type ElAbTe and 131.9 ha of vegetation type ChAmTe have been mapped outside of the Development Envelope, indicating that they are not restricted, and the proposed clearing will not significantly impact the regional extent of these vegetation types. Similarly, 50.1 ha of vegetation type AsTl and 47.6 ha of ElAmTe have been mapped outside of the Development Envelope, indicating that these vegetation types are not restricted to the Development Envelope and will continue to persist within the broader region.

Only a limited amount of CcaAiTe and ElAptTe vegetation types have been mapped beyond the Development Envelope. Detailed vegetation mapping has been completed for the Development Envelope and approximately 4351.17 ha beyond; however, it is not available for the broader Pilbara region. Therefore, broad-scale vegetation mapping has been used to assess the regional impacts of the loss of vegetation from the Development Envelope.

The vegetation types that occur within the Development Envelope are associated with four land systems – Capricorn, Robe, Rocklea and Taylor. Within 200 km of the Proposal, approximately 1,108,145 ha of these land systems are protected within conservation estate (namely Ex Meentheena Station Nature Reserve and Mungaroona Nature Reserve). The vegetation types are also associated with two Beard Vegetation Associations (171 and 173). After considering the cumulative impacts of the Proposal, greater than 98% of these vegetation associations will continue to persist throughout the Pilbara region (Table 7-13). Furthermore, approximately 149,845 ha of vegetation association 171 and 644,743 ha of vegetation association 173 are protected within conservation estate within 200 km of the Proposal. Given this, each of the vegetation types are considered not to be restricted to the Development Envelope and to occur throughout the wider Pilbara bioregion.

Given project flexibility, the location of infrastructure may change during implementation, and as such the total loss of each vegetation type within Table 7-8 may vary but will not exceed 1,913 ha. However, as there is no conservation significant vegetation and all types are anticipated to occur extensively beyond the Development Envelope, this flexibility is not expected to result in the significant loss of any vegetation type.

Table 7-17: Extent of vegetation types mapped outside of the Development Envelope

Vegetation type	Total extent mapped by Ecoscape 2020 survey (ha)	Approximate extent in Development Envelope (ha)	Approximate extent in Conceptual Footprint (ha)	Approximate % to be cleared from Development Envelope	Approximate % of total mapped extent to be cleared	Mapped extent remaining outside of Development Envelope (ha)
CcaAiTe	105.2	103.4	90.7	87.7	86.2	1.8
ElAbTe	1,769.3	891.8	550.9	61.8	31.1	877.5
ElAptTe	150.1	148.9	77.5	52.0	51.6	1.2
ElAmTe	73.1	25.5	21.3	83.5	29.1	47.6
AsTl	123.0	72.9	37.5	51.4	30.5	50.1
ChAmTe	630.1	498.2	393.1	78.9	62.4	131.9

7.6.1.2 Loss of Priority flora species

Based on the Conceptual Footprint, clearing for the Proposal will result in the direct loss of individuals of two Priority flora species, *Eragrostis crateriformis (*P3) and *Ptilotus mollis* (P4) (Table 7-7). One *Acacia aphanoclada* (P1) individual has been identified within the Conceptual Footprint and, given that it is the only individual of this species recorded within the Development Envelope, the Proponent has committed to the avoidance of this individual. One additional Priority flora species, *Rostellularia adscendens,* has been identified within the Development Envelope, but is not within the Conceptual Footprint and therefore is not anticipated to be impacted.

Based on the Conceptual Footprint, the Proposal will result in the direct loss of approximately 815 individuals of *E. crateriformis* or 60.4% of the total number of individuals recorded in the Development Envelope. *E. crateriformis* occurs across a 1,370 km range of Western Australia, with 51 population records from near the Tanami Desert to nearby Onslow (Woodman 2019b; ALA 2022). Furthermore, there are 18 population records of the species consisting of at least 2,976 individuals that have been recorded from nearby projects that are not proposed to be impacted (Table 7-15). As a Priority 3, this species has not been extensively surveyed, however given that there are 68 known location records containing at least 2,976 individuals that are widespread beyond the current Proposal and surrounding projects, and that the species is protected within conservation tenure (Millstream-Chichester National Park), the proposed clearing of the species is not considered to be a regionally significant impact.

Based on the Conceptual Footprint, approximately 842 individuals of *Ptilotus mollis* (P4) species will be cleared, or 14% of the total number of individuals recorded in the Development Envelope. *Ptilotus mollis* is endemic to Western Australia, with 34 location records over a range of 640 km, from Cane River Conservation Park in the west to Karlamilyi National Park in the east (Woodman 2018; ALA 2022). In addition, there are 50 location records of this species from nearby projects that are not expected to be impacted (Table 7-15). Based on the Conceptual Footprint, 225 populations of approximately 5,077 individuals will remain within the Development Envelope. Given the extensive range of *Ptilotus mollis* and that the species is protected within conservation tenure (namely Karijini National Park and Ex Meentheena Station nature reserve), the loss of the species is not considered to be a regionally significant impact.

No Threatened flora species have been recorded within the Development Envelope.

7.6.2 Indirect impacts

7.6.2.1 Introduction or spread of weeds

The Proponent has established weed and hygiene management measures to reduce the risk of existing weeds being spread or new weeds being introduced into the Development Envelope. These measures are outlined in the Terrestrial Fauna Management Plan (Appendix M) and include weed control including in areas around the clearing front and in retained native vegetation adjacent to cleared areas. In particular, the Proponent will undertake targeted control of the one declared weed, Rubber bush, which is already present in the Development Envelope, to avoid the spread of this existing weed into new cleared areas and uninfested areas.

On this basis, the Proposal is considered unlikely to significantly impact the condition of native vegetation through the spread or introduction of weed species. Any impacts are predicted to be localised to disturbed areas and will have no impact on vegetation regionally.

7.6.2.2 Degradation or alteration of vegetation as a result of altered surface water flows around infrastructure

The Proposal is not expected to significantly impact the creekline catchments. McPhee Creek, Branch of McPhee Creek and Sandy Creek may experience catchment reductions of around 10% as a result of mining infrastructure. Spinaway Creek may experience minimal catchment loss, and no loss is expected for Lionel Creek. Some catchment flows are expected to be reinstated at closure. Impacts to vegetation as a result of altered hydrological regimes will be managed through the implementation of the WMP (Appendix B). Given the rainfall patterns of the Pilbara, where most rainfall is episodic with generally short periods of runoff and creek flow, a small reduction in catchment and peak flows is unlikely to change the hydrological regime to the extent that it affects any environmental values.

7.6.2.3 Impacts to groundwater dependent vegetation as a result of groundwater drawdown from mine dewatering

Based on the very slow rate of drawdown in the underlying aquifers and the regular recharge of the alluvial systems where potential GDV occurs, the risk of impact to GDV as a result of dewatering is expected to be low. Minor changes to vegetation health (i.e. a non-permanent reduction in plant health, usually a straight reduction in canopy cover) within potential GDV areas inside the Development Envelope may occur (47.5 ha). This could include a small reduction in canopy cover in comparison to reference sites during drought periods and would not be expected to result in areas of mortality. Beyond the Development Envelope, the rates of drawdown in potential GDV areas are modelled to be less than 2 cm/year and therefore there is negligible potential for change in these areas.

The GDV vegetation that may be affected by minor changes to vegetation health is not conservation significant and these vegetation types are widespread and common along drainage lines in the region. Therefore, the non-permanent minor change to vegetation health in GDV, if it occurs, is not considered significant.

7.6.2.4 Impacts to riparian vegetation as a result of surplus water discharge to surface water systems

Discharge of surplus water to surface water systems is a common practice at many operations in the Pilbara. Controlled discharge to the creeks nearby the Proposal will not be continuous and peak discharge will occur early in mine life. It is likely that the maximum wetting fronts on each creek would only be reached for a short time (one to three years), if at all. These maximum wetting fronts also allow flexibility to vary the discharge in the creeks which will be more consistent with the natural variability in flow rates and less likely to create long term mounding in the alluvial aquifer which could cause waterlogging for deep rooted vegetation and associated change to vegetation types. Discharges are not expected to have a significant impact to the riparian vegetation values along these creeks due to the short term nature of peak discharges and the adaptation of these creeks to highly variable flows. Following cessation of dewatering, the hydrological regimes will return to pre-mining conditions with long dry periods and slightly reduced peak flows due to catchment reduction.

7.6.2.5 Degradation of vegetation through dust deposition

The Proposal will result in dust emissions from clearing for construction and operation of the Proposal. Matsuki et al. (2016) conducted a study examining the impacts of dust on plant health in semi-arid environments. The study found no evidence of negative impacts on plant health for dust deposition in semi-arid environments. Plants in semi-arid environments are exposed to dust naturally and may be less likely to suffer from short-term impacts of dust.

An air quality assessment determined that dust deposition is mostly limited to the Conceptual Footprint of the Proposal (ETA 2021). The Proponent will implement dust management measures to reduce dust emissions and subsequent deposition, throughout the Development Envelope. The Proponent will implement standard dust management procedures throughout the life of mine. The Proposal may result in a minor, temporary increase in localised dust deposition on vegetation but is not expected to significantly impact vegetation, noting that the Pilbara is a naturally dusty environment.

7.6.3 Cumulative impacts

7.6.3.1 Cumulative impacts on native vegetation

The Proposal will result in the clearing of up to 1,913 ha of native vegetation in addition to the potential clearing of approximately 159,000 ha from other projects within 200 km of the Proposal. The current (2018) extent of vegetation within the Pilbara region is 17,731,765 ha (GoWA 2019). Based on the predicted impacts, clearing for the Proposal will contribute a further 0.01% to vegetation clearing within the bioregion (Table 7-12).

The Proposal will result in the clearing of two vegetation associations (171 and 173) that occur throughout the Pilbara bioregion. The cumulative impact of this clearing from existing and reasonably foreseeable projects within 200 km of the Proposal indicate that at least 98% or more of the pre-European extent of each of the vegetation associations present within the Development Envelope will remain across the Pilbara Bioregion (Table 7-13).

The Proposal will also contribute to the cumulative clearing of four land systems that occur within the Chichester subregion: Capricorn, Robe, Rocklea and Taylor. The greatest cumulative impact is to the Robe land system, with an estimated 28% loss of this land system from the subregion. However, these calculations are highly conservative as they considered the extent of the land system throughout the development envelopes of each surrounding project and did not assess the actual disturbance. Cumulative clearing in the Pilbara bioregion has been identified by the EPA as an area of concern (EPA 2014). Without the implementation of the strategies the EPA has outlined, it is believed that cumulative impacts of development in the Pilbara would have a significant effect on biodiversity and environmental values of the region. The Pilbara Environmental Offsets Fund therefore aims to improve the conservation of biodiversity in the Pilbara. As the clearing of 1,913 ha of native vegetation associated with the Proposal is considered to be a significant cumulative impact, environmental offsets are proposed for vegetation within Good to Excellent condition and riparian vegetation (Section 13).

7.6.3.2 Cumulative impacts on Priority flora species

Based on the Conceptual Footprint, clearing for the Proposal is likely to result in loss of individuals of three Priority listed flora species: *Eragrostis crateriformis, Ptilotus mollis* and *Acacia aphanoclada* (noting the latter specimen will be avoided). The cumulative impact of the Proposal and nearby projects to *Ptilotus mollis* and *Eragrostis crateriformis* is the loss of approximately 59 and 34 population records, respectively. However, both the Proposal and surrounding projects are expected to avoid impacts to a number of populations and individuals. A total of 275 population records with at least 5,077 individuals of *Ptilotus mollis* are anticipated to be avoided, and a total of 122 populations with at least 15,548 individuals of *Eragrostis crateriformis* are expected to be avoided.

Both the *Ptilotus* and *Eragrostis* species are widespread throughout the Pilbara region, as well as protected within conservation tenure (see Section 7.6.1.2). As such, there is not expected to be a significant cumulative impact of the clearing of individuals of these species.

The predicted cumulative impact on Priority flora species within the Development Envelope is not considered to be significant and is unlikely to alter the conservation status for any of the Priority flora species within the Development Envelope.

7.7 Environmental outcomes

The outcomes of the assessment of potential impacts and proposed mitigation measures to protect environmental values associated with flora and vegetation meet the EPA's objective for this factor. The predicted environmental outcomes for flora and vegetation are summarised as follows:

- Clearing of up to 1,913 ha of native vegetation in excellent to good condition.
- All vegetation types occur extensively beyond the Development Envelope and no significant impact is expected regardless of the final location of footprint within the Development Envelope.
- Loss of individuals from two Priority flora species as identified in Table 7-18. The *Acacia aphanoclada* individual within the Conceptual Footprint will be avoided. The other species are all known to occur widely and the removal of individuals within the Development Envelope is not considered significant.

Table 7-18: Indicative clearing values for Priority Flora species

Priority Flora Species	Conceptual Footprint (No. individuals, % of records in Development Envelope)
Acacia aphanoclada (P1)	1 (100%)*
Eragrostis crateriformis (P3)	815 (60.5%)
Ptilotus mollis (P4)	842 (14.2%
Rostellularia adscendens (P3)	0 (0%)

*Proponent has committed to the avoidance of this individual

- Impacts from groundwater drawdown are not predicted to impact potential GDV within, or beyond, the Development Envelope due to the very slow rate of drawdown in the underlying aquifers and the regular recharge of alluvial systems where potential GDV occurs.
- Surplus water discharge is not expected to significantly impact riparian vegetation due to the short term nature of peak discharges and the adaptation of creeks to highly variable flows.
- Spread of weeds and dust deposition are expected to be managed within the Development Envelope through the application of standard weed and dust management measures and not result in a significant increased risk as a result of implementation of the Proposal.
- No listed threatened flora species, TECs or PECs are present within the Development Envelope.

7.8 Conclusion

The significant residual impact, after the implementation of the mitigation hierarchy, is clearing of up to 1,913 ha of native vegetation, in Good to Excellent condition. Environmental offsets are proposed for the clearing of native vegetation and are discussed in Section 13. The Proponent therefore considers the Proposal can be managed to meet the EPA's objective to *protect flora and vegetation so that biological diversity and ecological integrity are maintained.*

8 Terrestrial Fauna

8.1 EPA environmental factor objective

The EPA's objective for terrestrial fauna is *to protect terrestrial fauna so that biological diversity and ecological integrity are maintained* (EPA 2021c).

8.2 Relevant policy and guidance

The relevant policy and guidance for Terrestrial Fauna are described in Table 8-1.

Table 8-1: Relevant Policy and Guidance for Terrestrial Fauna

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
Environmental Protection Authority	
Instructions on how to prepare an Environmental Review Document (EPA 2021d)	Considered during the development of this document
Statement of Environmental Principles, Factors and Objectives (EPA 2021c)	
Environmental Factor Guideline: Terrestrial Fauna (EPA 2016d)	Considered in the design (methods and approach) of the terrestrial fauna surveys or previous guidance (if survey undertaken before current guidelines)
Technical Guidance: Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA 2020c)	
Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016j)	
Technical Guidance: Sampling of Short-Range Endemic Invertebrate Fauna (EPA 2016g)	
Instructions on how to prepare environmental Protection Act 1986 Part IV Impact Reconciliation Procedures and Impact Reconciliation Reports (EPA 2021a)	Considered in the development of this document and for the Impact Reconciliation Procedure (Appendix K)
Template for Environmental Protection Act 1986 Part IV Reconciliation Procedures (EPA 2021b)	
Other State or Commonwealth	
DMIRS Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines (DMIRS 2020c)	Considered in the development of this document and for the Mine Closure Plan (Appendix A)
Statutory Guidelines for Mine Closure Plans (DMIRS 2020b)	
Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986 (EPA 2014)	Considered in the impact assessment and offset strategy for terrestrial fauna
WA Environmental Offsets Policy (GoWA 2011)	
WA Environmental Offsets Guidelines (GoWA 2014).	

Additional policies and guidance that have been considered for MNES species are outlined in Section 12.

8.3 Receiving environment

8.3.1 Studies and survey effort

The terrestrial fauna habitat and values in the Development Envelope are well understood. Numerous surveys have been conducted over many years, including baseline surveys, targeted conservation significant species surveys and targeted short-range endemic (SRE) surveys (Table 8-2). All fauna surveys have been conducted in accordance with the relevant guidance outlined in Section 8.2.

Details of the survey effort for both vertebrate fauna and SRE invertebrate fauna are provided in Table 8-2, with the consolidated extent of the surveys shown on Figure 8-1 and Figure 8-2. Details of the sampling sites and techniques are shown in Figure 8-3 for vertebrate fauna and Figure 8-4 for SREs.

Surveys were first commenced in the Development Envelope in 2011 in relation to a previous development concept. Outback Ecology (2012b) conducted a two-phase Level 2 terrestrial vertebrate fauna baseline survey in 2011 and 2012, and a baseline SRE invertebrate fauna survey in 2012 (Outback Ecology 2013b). The results of these surveys informed several targeted surveys conducted from 2012 to 2014 for conservation significant species, including Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Greater Bilby and SRE invertebrate fauna. Further discussion of these targeted surveys for MNES species is provided in Section 12.

Since that time, the Proposal has been substantially revised. Given the time lapsed and after a fire destroyed vegetation within the Spinifex Sandplain habitat type in early 2015, several additional vertebrate fauna surveys were conducted in 2020 and 2021 to consolidate existing survey information, provide full Level 2 survey coverage and confirm targeted species occurrence. A consolidated vertebrate fauna species list from the desktop assessment is also provided in Appendix C of the *McPhee Creek Consolidated Terrestrial Fauna Report* (Biologic 2021a Appendix N).

Table 8-2: Terrestrial fauna surveys conducted within the Development Envelope

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
Terrestrial Fauna				
McPhee Creek Project Terrestrial Vertebrate Fauna Baseline Survey (Outback Ecology 2012b)	September 2011 and February/March 2012	Detailed	• Systematic trapping (10 sites) • Trapping (5,292 trap nights) • Systematic hand searching (27 person hours) • Avifauna census (42 person hours) • Spotlighting (18 person hours) • Targeted searches (25.5 person hours) and motion-sensor cameras (58 camera trap nights) • Targeted bat surveying (61 recording nights) • Opportunistic records	• Northern quoll (24 records) • Pilbara leaf-nosed bat (25 individuals) • Ghost bat (3 records) • western pebble-mound mouse (14 records) • Long tailed-dunnart (1 record) • Pilbara olive python (3 records)
East West Rail Spur Project Terrestrial Vertebrate Fauna Baseline Survey (Outback Ecology 2013a)	June/July 2013	Detailed	This survey is included as it covered the western portion of the Development Envelope that connects McPhee Creek to the Greater Northern Highway. Survey effort consisted of: • Trapping (4,116 trap nights) • Systematic hand searching (21 person hours) • Avifauna census (32.5 person hours) • Spotlighting (14 person hours) • Targeted searching (24 person hours) • Motion-sensor cameras (88 camera nights) • Conservation significant bat survey (44 recording nights) • Opportunistic records	• Northern quoll (6 occurrences of scats or tracks) • Greater bilby (10 tracks and one scat observed) • Pilbara leaf-nosed bat (records from 10 of the 27 sites) • Ghost bat (1 scat)

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
McPhee Creek Haul Road Project Terrestrial Vertebrate Fauna Survey (Outback Ecology 2014a)	June/July 2013 and March 2014	Detailed	• Systematic trapping (14 sites) • Trapping (9,464 trap nights) • Systematic hand searching (39 person hours) • Avifauna census (60.5 person hours) • Spotlighting (12 person hours) • Targeted searching (110.5 person hours) • Motion-sensor cameras (147 camera trap nights) • Targeted bat survey (55 recording nights) • Opportunistic records	• Northern quoll (15 records of scats) • Greater bilby (11 occurrences of scats, tracks or burrows) • Pilbara leaf-nosed bat (16 records) • Pilbara olive python (1 track recorded)
McPhee Creek Mine and Rail Project Terrestrial Vertebrate Fauna Survey (MWH 2014d)	May and June 2014	Desktop and single phase Level two survey	• Systemic sampling involving trapping, hand-searching, fixed-time avifauna censusing and night spotlight searches (7 sites) • Eight targeted searches totalling 25 person hours • Motion-sensor cameras deployed at 27 locations • Bat echolocation recorders at eight locations • Opportunistic records •	• Northern Quoll (2 scats) • Greater Bilby (2 individuals recorded via camera, five occurrences of burrows or diggings) • Pilbara Leaf-nosed Bat (Calls recorded at 5 locations) • Western Pebble-mound Mouse (One individual recorded via camera and 7 potentially active mounds)
McPhee Creek Consolidated Terrestrial Fauna Report (Biologic 2021a; Appendix N)	Trip 1: 31st March – 8th April 2020 Trip 2: 15 – 25th June 2020	Consolidated report including previous surveys and a basic/targeted	**Basic/Targeted Survey:** • Habitat assessments (158 sites) • Cave assessments (20 sites) • Water feature assessments (25 sites) • Ultrasonic bat recording (139 night at 101 sites)	• Northern Quoll (7 records from scats including once in the Significant Fauna Exclusion Zone) • Pilbara Leaf-nosed Bat (calls recorded 74 times at 62 sites) • Ghost Bat (recorded ten times)

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
	Trip 3: 25 – 30th August 2020	survey from 2020	• Acoustic recording targeting Night Parrot (60 recording nights at 10 locations) • Motion cameras targeting Northern Brushtail Possum (100 motion camera nights at 2 locations) • Targeted searches for Ghost Bat, Pilbara Leaf-nosed Bat, Greater Bilby, Northern Quoll, Pilbara Olive Python and Northern Brushtail Possum (137.2 person hours at 83 sites) • Nocturnal searches • Opportunistic records	• Pilbara Olive Python (recorded 2 times)
Northern Quoll				
McPhee Creek Iron Ore Project Northern Quoll Baseline Monitoring (Outback Ecology 2012a)	August 2012	Targeted	• Targeted trapping (1,140 trap nights)	• Northern Quoll (10 individuals comprising 7 males and 3 females)
McPhee Creek 2014 Northern Quoll Monitoring Survey (MWH 2014b)	July 2014	Targeted	• Northern Quoll targeted trapping (500 trap nights) • Opportunistic recording	• One individual Northern Quoll (adult female) as well as opportunistic records at eight locations
McPhee Creek Consolidated Terrestrial Fauna Report (Biologic 2021a; Appendix N)	Trip 1: 31st March – 8th April 2020 Trip 2: 15 – 25th June 2020	Consolidated report including previous surveys and a basic/targeted	**Basic/Targeted Survey:** • Habitat assessments (158 sites) • Cave assessments (20 sites) • Water feature assessments (25 sites) • Targeted searches for Northern Quoll	• Northern Quoll (7 records from scats including once in the Significant Fauna Exclusion Zone)

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
	Trip 3: 25 – 30th August 2020	survey from 2020	• Nocturnal searches • Opportunistic records	
Pilbara Leaf-nosed Bat and Ghost Bat				
McPhee Creek Project Targeted Pilbara Leaf-nosed Bat Survey (Outback Ecology 2013c)	April/May 2012	Targeted (Pilbara Leaf-nosed Bat)	• 31 potential sites surveyed	• Pilbara Leaf-nosed Bat (17 sites) • Ghost Bat (6 sites)
McPhee Creek Mine and Rail Project: Pilbara Leaf-nosed Bat and Ghost Bat monitoring 2014 (MWH 2014c)	July 2014	Targeted (Pilbara Leaf-nosed Bat and Ghost Bat)	• Bat echolocation recording • Opportunistic observations	• Pilbara Leaf-nosed Bat (4 sites) • Ghost Bat (1 site)
McPhee Creek Pilbara Leaf-nosed Bat Review (Bat Call WA 2020)		Desktop review	A desktop review that summaries the results of echolocation surveys completed by Biologic for the presence of Pilbara Leaf-nosed Bat at the proposed McPhee Creek Proposal area. The review summarised the surveys' results, confirmed the presence of a permanent diurnal roost, and suggested a possible location for the diurnal roost. Note that this was discounted by Biologic in a recent survey outlined below (2022b).	
McPhee Creek Pilbara Leaf-nosed Bat Survey Results (Bat Call WA February 2021a)		Desktop review of field studies	Key findings include the presence of a Pilbara Leaf-nosed Bat diurnal roost and indication of where the roost may be located, along with the evidence	

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
			of a small colony of bats contained in the roost. The surveys also provided evidence of the species foraging pattern along ridgelines. Note that this was discounted by Biologic in a recent survey outlined below (2022b).	
McPhee Creek Pilbara Leaf-nosed Bat Survey Results (Bat Call WA March 2021b)		Desktop review of field studies	Review of three recent field surveys and additional fourth targeted and interactive search for Pilbara Leaf-nosed Bat. The findings of this review indicated that there was opportunistic diurnal roosting within the development envelope; however, no permanent diurnal roost was located.	
McPhee Creek Targeted Pilbara Leaf-nosed Bat Survey (Biologic 2022b; Appendix O)	June and August 2020	Targeted (Pilbara Leaf-nosed Bat)	• Ultrasonic recorded (deployed at 77 locations for a single night each)	• Pilbara Leaf-nosed Bat (recorded at 29 sites, with 37 calls recorded at caves and 74 calls recorded at water features) • Ghost Bat (4 scats and 1 individual) • Northern Quoll (5 scats) • Pilbara Olive Python (1 individual) • Western Pebble-mound Mouse (one recently inactive mound) •
McPhee Creek – Bat Caves Geotechnical Assessment (PSM 2022; Appendix P)	March 2022	Geotechnical assessment	• An assessment of four bat caves (CMPC-10, 13, 21 and 25) for geotechnical stability.	
Greater Bilby				

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
McPhee Creek Iron Ore Project Targeted Bilby Survey (Outback Ecology 2014b)	March, July and August 2013	Targeted	• Targeted Greater Bilby searches (27 searches) • Motion-sensor cameras (142 camera nights) • Opportunistic observations	• Greater Bilby (16 burrows with nocturnal images of a Greater Bilby captured at ten of these, although the number of individuals was estimated to be two)
McPhee Creek 2014 Bilby Monitoring Survey (MWH 2014a)	July 2014	Targeted	• Greater Bilby targeted searches (6 person hours) • Opportunistic recording • Motion-sensor cameras (108 camera nights at 26 Greater Bilby burrows)	• Greater Bilby presence confirmed, however, it may be represented by only a single individual
McPhee Creek Consolidated Terrestrial Fauna Report (Biologic 2021a; Appendix N)	Trip 1: 31st March – 8th April 2020 Trip 2: 15 – 25th June 2020 Trip 3: 25 – 30th August 2020	Consolidated report including previous surveys and a basic/targeted survey from 2020	**Basic/Targeted Survey:** • Habitat assessments (158 sites) • Targeted searches for Greater Bilby • Nocturnal searches • Opportunistic records	• No Greater Bilby recorded
Short-range Endemic Invertebrates				
Terrestrial SRE Invertebrate Fauna Baseline Survey January 2013 (Outback Ecology 2013b)	February and March 2012	Desktop assessment and Level 2 invertebrate fauna survey	• Methods included wet pitfall trapping, targeted searches and soil and litter collection at 18 systematic sample sites and 7 target sample sites. • 4,500 total trapping nights • 72 hours of targeted searching • Collection of 54 soil samples and 54 leaf litter samples	• 8 broad habitats identified • 380 invertebrate specimens from 21 identifiable species • Six Potential SRE species

Survey title	Year of survey	Survey type	Survey effort	Conservation significant species recorded
			• Fauna habitat assessment conducted over entire survey area	
McPhee Creek Project Short-Range Endemic Invertebrate Fauna Desktop Assessment (Biologic 2019a)		Desktop assessment	Desktop assessment of SRE terrestrial invertebrate fauna for the McPhee Creek project. The report provides more detailed species and habitat information from baseline surveys. The report identified the need for an informed subsequent dry season survey.	
McPhee Creek Short-Range Endemic Invertebrate Fauna Survey (Biologic 2019b; Appendix Q)	October 2019	SRE field survey (dry season)	• 35 sites sampled for habitat assessment • 26 sites sampled for SRE invertebrates	• 59 invertebrate specimens collected • No Confirmed SRE taxa identified • Ten taxa considered as Potential SRE
McPhee Creek Short-range Endemic Invertebrate Fauna Survey Memo (Biologic 2020f; Appendix Q)		Desktop assessment	A brief memo consolidating the habitat analyses of Biologic's (2019a) McPhee Creek Short-range Endemic Invertebrate Fauna Survey and Biologic's (2020c) McPhee Creek Consolidated Terrestrial Fauna Report.	

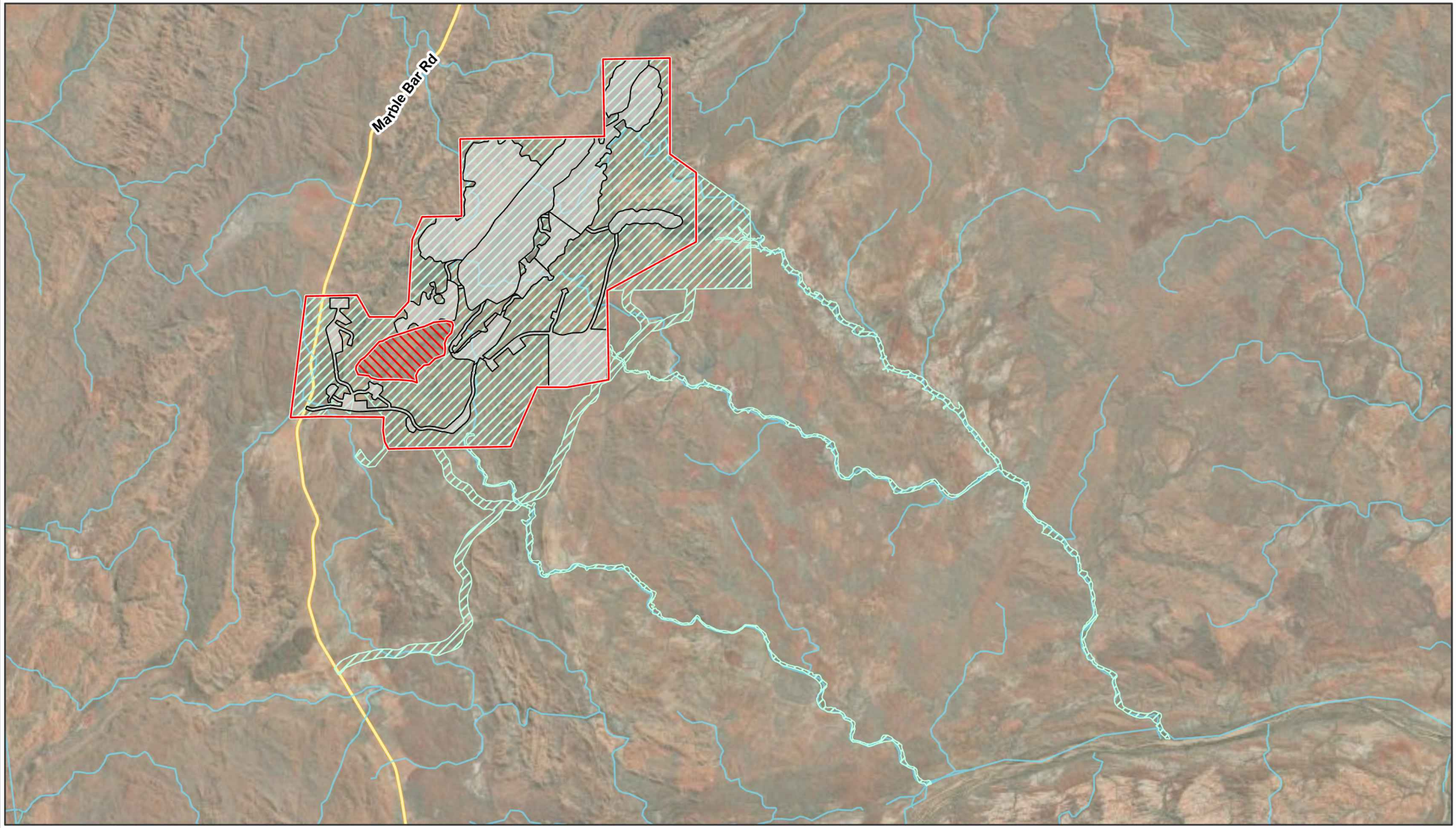

Figure 8-1: Consolidated extent of terrestrial fauna surveys within and adjacent to the Development Envelope 2011-2021

Development Envelope
Exclusion Area
Conceptual Footprint
Biologic Survey Area (2020)
Distributor Road
Access Road
Drainage (Statewide)

0 1 2 4
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 50
Project: 15064-DD Date: 13/04/2022

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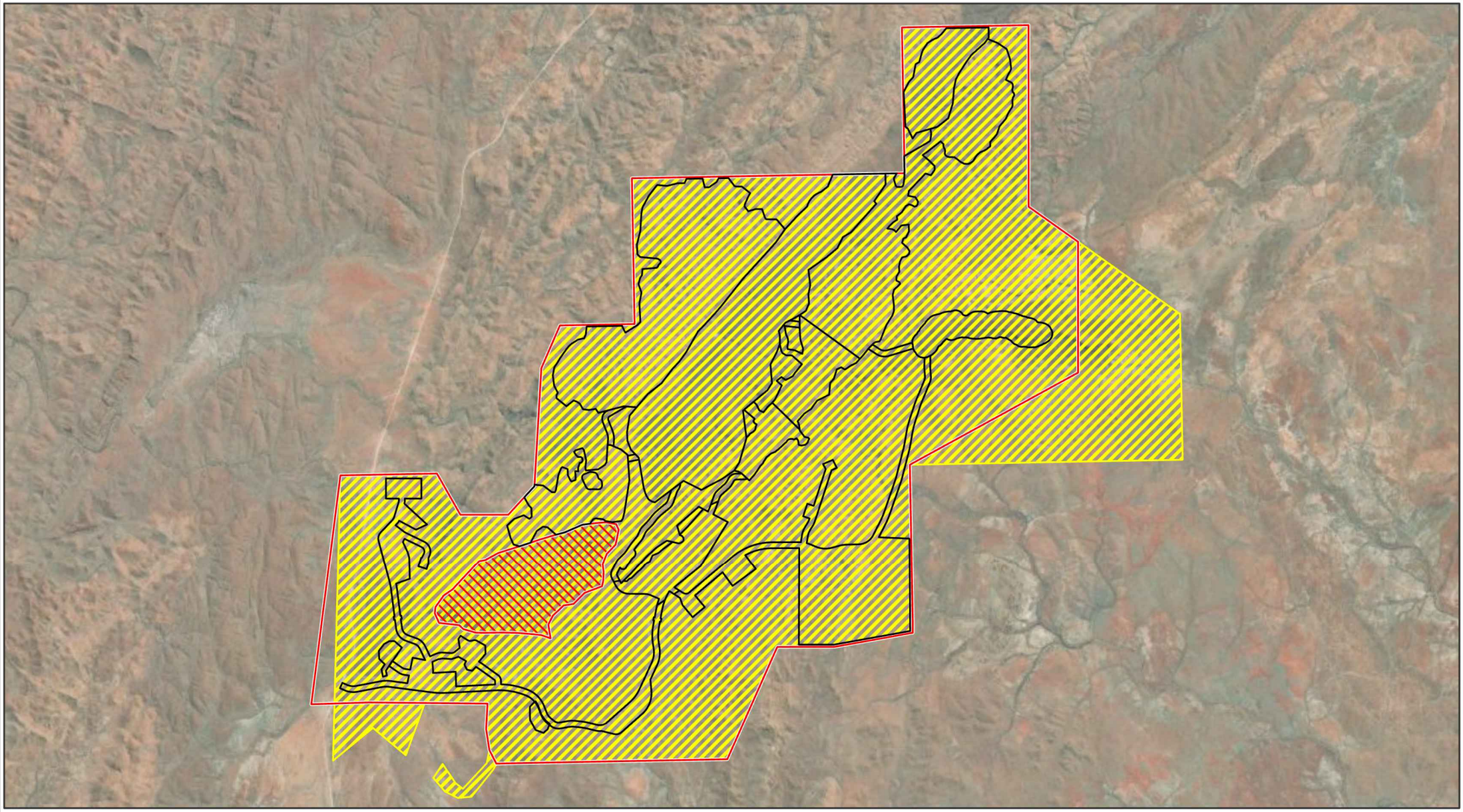

Figure 8-2: Consolidated extent of SRE terrestrial invertebrate fauna surveys within and adjacent to the Development Envelope 2013-2020

Development Envelope

Significant Fauna Exclusion Zone

Conceptual Footprint

Consolidated SRE Surveys 2013-2020

0 0.5 1 2

Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 13/04/2022

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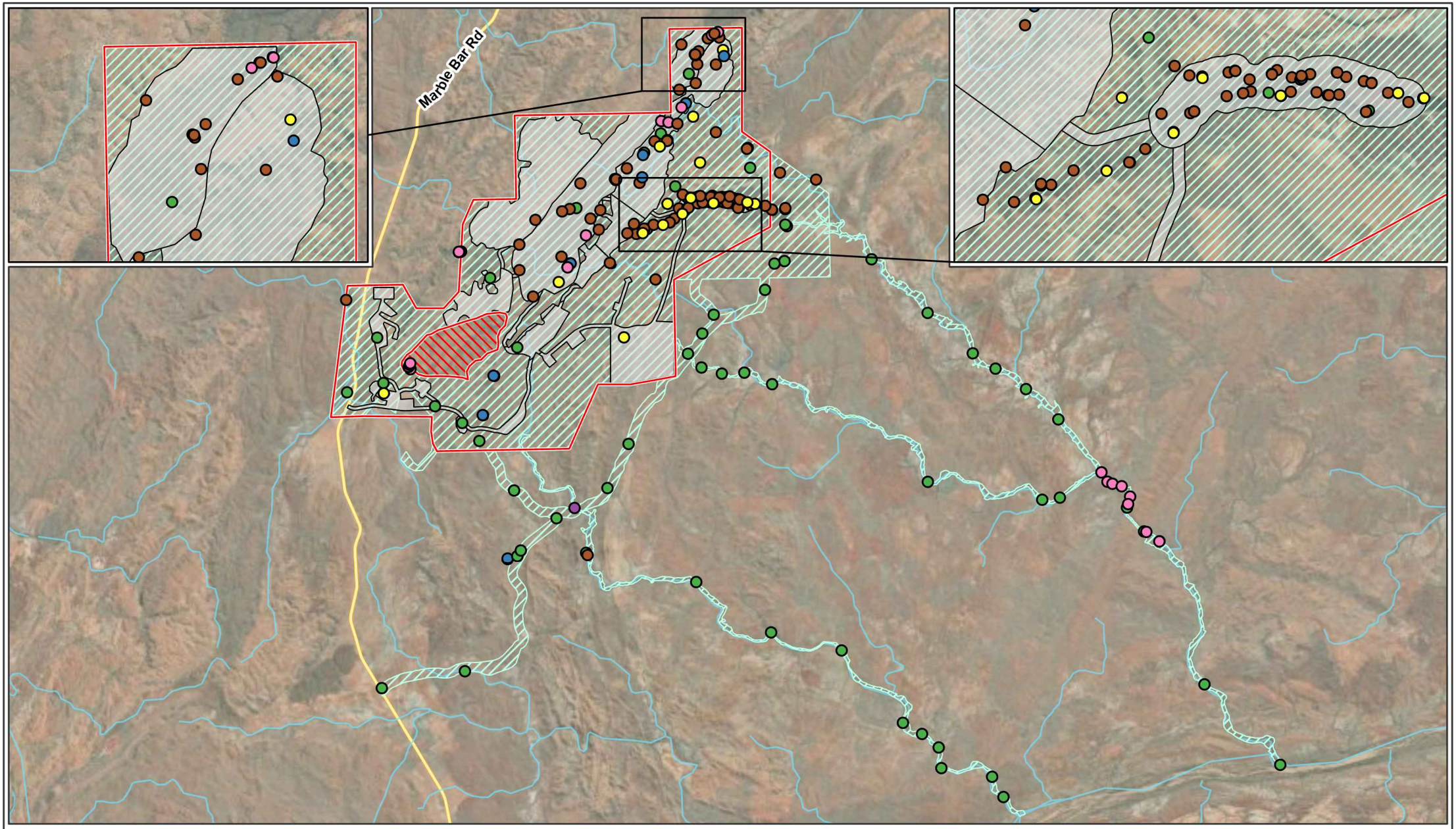

Figure 8-3: Terrestrial Fauna Sampling Sites

- Development Envelope
- Significant Fauna Exclusion Zone
- Conceptual Footprint
- Consolidated Terrestrial Fauna Surveys 2011-2021
- Distributor Road
- Access Road
- Drainage (Statewide)

Sampling Technique

- Acoustic recording
- Cave assessment
- Habitat assessment
- Motion camera
- Nocturnal survey
- Targeted search
- Ultrasonic bat recording
- Water feature assessment

0 0.28 0.55 1.1
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 50
Project: 15064-DD Date: 13/04/2022

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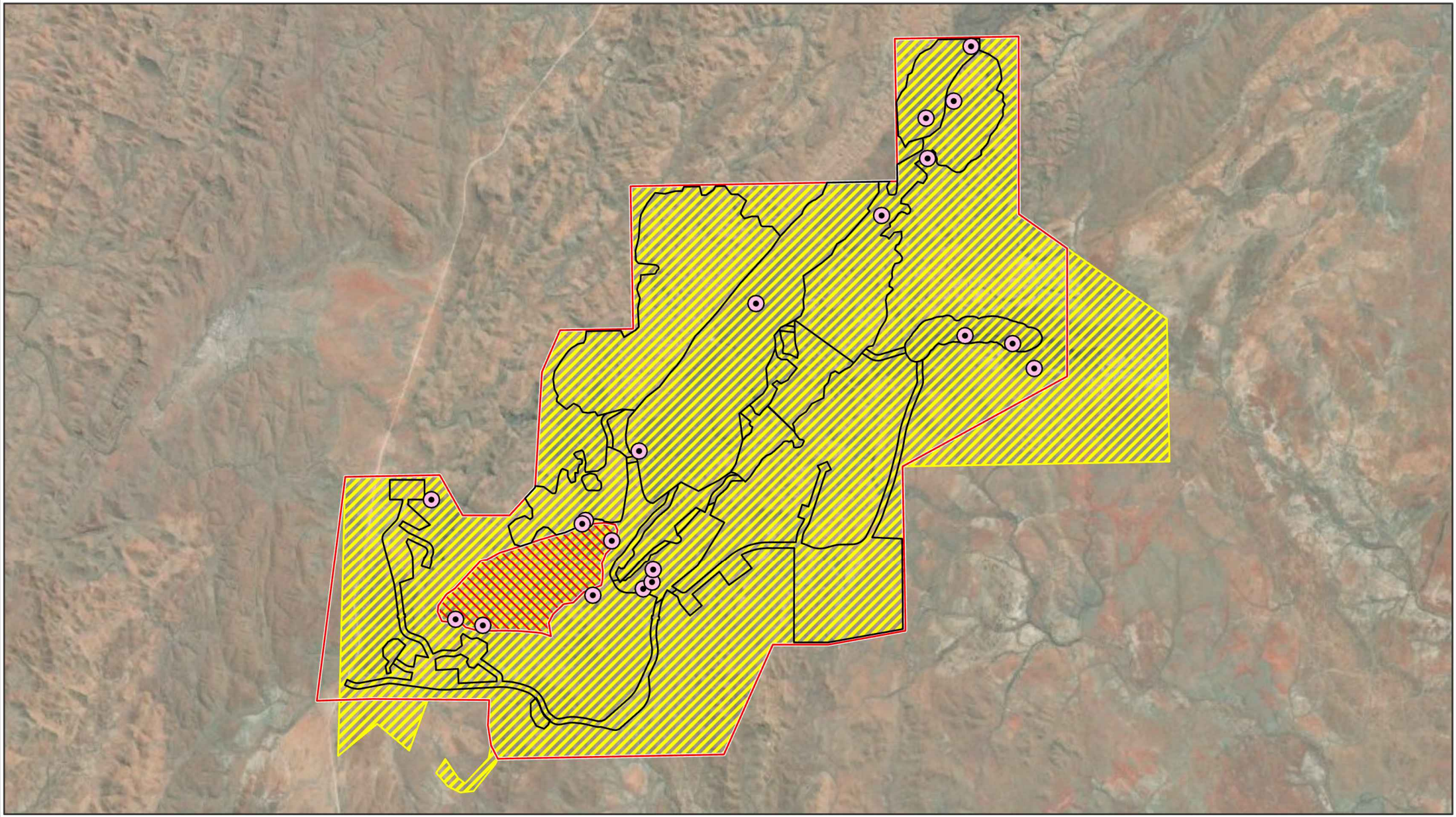

Figure 8-4: SRE Fauna Sample Sites

Development Envelope
Significant Fauna Exclusion Zone
Conceptual Footprint
SRE Sample Sites
Consolidated SRE Surveys 2013-2020

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 13/04/2022

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8.3.2 Terrestrial fauna habitat

A total of eight terrestrial fauna habitat types have been mapped in the Development Envelope (Biologic 2021a, Table 8-3 and Figure 8-5).

The highest value fauna habitat types for fauna species known or likely to occur in the Development Envelope are Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope, Drainage Line and Spinifex Sandplain. These habitat types provide high value denning/burrowing, roosting and/or foraging habitats for conservation significant fauna. The remaining habitat types are considered moderate to low value and are common and widespread in the region (Biologic 2020b). The Rocky Foothills habitat provides high-quality foraging and dispersal habitat; however, remains of moderate value overall.

Table 8-3: Terrestrial fauna habitats mapped in the Development Envelope

Terrestrial fauna habitat type	Description and distribution	Value	Extent within the Development Envelope (ha)	Extent outside of the Development Envelope and SFEZ mapped by Biologic (2021a) (ha)
Gorge/Gully	Gorge/Gully habitat comprises rugged, sometimes steep-sided rocky valleys incised into the surrounding landscape forming shallow gullies and gorges. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are shallower and more open. Caves are most often encountered in this habitat type. Vegetation within this habitat is variable depending on position in landscape and can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred. Well represented throughout the region and the conservation estate.	**High value** Suitable shelter/denning/roosting, foraging and dispersal habitat for conservation significant species.	141.5	0
Breakaway/Cliff	Characterised by a linear flat-topped platform of ironstone with limited vegetation cover comprising soft and hard spinifex and scattered Eucalyptus trees and shrubs. Well represented throughout the region.	**High value** Suitable shelter/denning/roosting, foraging and dispersal habitat for conservation significant species.	26.3	1.3

Terrestrial fauna habitat type	Description and distribution	Value	Extent within the Development Envelope (ha)	Extent outside of the Development Envelope and SFEZ mapped by Biologic (2021a) (ha)
Drainage Line	Drainage Line habitat is variable in structure and condition. Vegetation within this habitat is often dominated by *Eucalyptus* species over a variable understory comprising mixed small to medium shrubs and tussock grasses. Various temporary, semi-permanent to permanent water holes are present in this habitat type. Widespread throughout the region although condition is variable and susceptible to degradation.	**High value** High quality foraging and dispersal habitat for a wide range of species, including conservation significant species.	182.2	421.5
Hillcrest/Hillslope	The Hillcrest/ Hillslope habitat is characterised by a predominant ironstone substrate with broken rock exposures descending into dense growth of Acacia in drainage, with deep leaf litter, rubble and gravel. Eucalyptus, Acacia and Grevillea sp. (trees and shrubs), with banks of dense Spinifex, Cymbopogon and other tussock grasses. Widespread throughout the region.	**High value** Suitable shelter/denning/roosting, foraging and dispersal habitat for conservation significant species.	707.9	1.8
Spinifex Sandplain	Low to flat topography on dominant sandy soils with soft spinifex and *Acacia* shrubs. Limited in the survey area.	**High value** Suitable for burrowing, foraging and dispersal habitat for Greater Bilby.	67.0	2.6
Rocky Foothills	Low undulating rocky hills intersected by minor drainage lines forming gullies with some small rocky exposures. This habitat supports hard spinifex with a mantle of gravel and pebbles. Widespread and common in the region.	**Moderate value** Suitable foraging and dispersal habitat for conservation significant species.	2,198.4	253.5

Terrestrial fauna habitat type	Description and distribution	Value	Extent within the Development Envelope (ha)	Extent outside of the Development Envelope and SFEZ mapped by Biologic (2021a) (ha)
Spinifex Stony Plain	Flat to low undulating areas with vegetation dominated by *Triodia* hummock grasses of various life stages and scattered patches of small to medium shrub species on gravelly clay loam substrates. Common and widespread in the region.	**Low value** This is one of the most common and widespread habitat types within the Pilbara region and does not contain any important habitat features for conservation significant fauna.	1,059.4	385.0
Calcrete	Spinifex hummock grassland over a stony, calcareous substrate. It is a gently undulating plain with scattered *Corymbia* trees and *Acacia* shrubs. Widespread throughout the region.	**Low value** Widespread and well represented within the Pilbara. No rocky features comprising of caves, crevices or outcroppings present.	82.3	110.7
TOTAL			**4,465**	**1176.4**

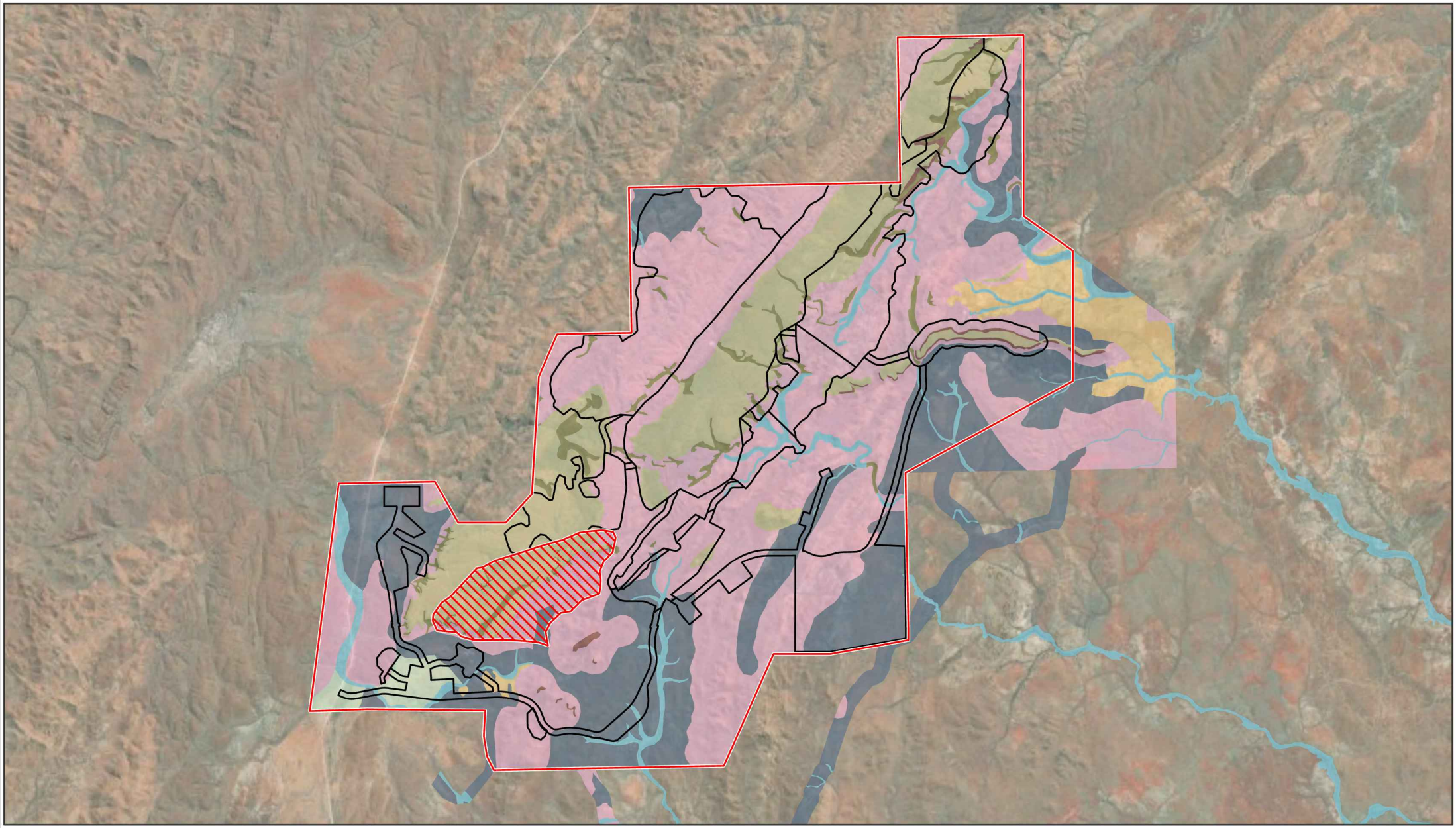

Figure 8-5: Terrestrial fauna habitat types mapped within and adjacent to the Development Envelope

8.3.2.1 Regional extent of fauna habitat

Detailed fauna habitat mapping has been completed for the Development Envelope and surrounds, however it is not available at this level for the broader Pilbara region. Nevertheless, an assessment of regional land systems provides an indication of the diversity and distribution of fauna habitats present surrounding the Development Envelope as Van Vreeswyk et al. (2004) classified and mapped the land systems of the Pilbara according to similarities in landform, soil, vegetation, geology and geomorphology.

The dominant land systems within the Development Envelope are also the dominant land systems surrounding the Development Envelope: Rocklea and Capricorn land systems (Table 8-4 and Figure 8-6). Capricorn and Rocklea land systems cover 54.8% and 34.6% of the Development Envelope, respectively. Within 20 km of the Development Envelope (buffer taken from the centre of the Development Envelope but calculations not including within the Development Envelope), there is 86,909.96 ha mapped as Rocklea and 25,158.09 ha mapped as Capricorn land systems.

The Rocklea land system comprises ridges, mountains and gorges which often hosts important caves, refugia and foraging opportunities for many species of conservation significance present in the region. In the Development Envelope, the Rocklea land system was mapped as predominantly Rocky Foothills and Spinifex Stony Plain habitat, but also included Calcrete Plain habitat.

The Capricorn land system is defined as 'hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands'. In the Development Envelope the Capricorn land system was predominately mapped as Hillcrest/Hillslope, Gorge/Gully, Rocky Foothills and Breakaway/Cliff habitat.

Smaller areas of the Taylor land system also adjoins the Development Envelope. The Taylor land system comprises stony plains and isolated low hills of sedimentary rocks supporting hard and soft spinifex grasslands. The Taylor land system mapped within the Development Envelope corresponds with Spinifex Stony Plain and Spinifex Sandplain habitat. Approximately 4,911.41 ha of this land system has been mapped within the 20 km buffer of the Development Envelope.

The only presence of Robe land system within the 20 km buffer zone is within the Development Envelope. The Robe system is described as low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands. The Robe land system mapped in the Development Envelope corresponded to a mix of habitats that are associated with the other aforementioned land systems: Hillcrest/Hillslope, Breakaway/Cliff, Rocky Foothills, Spinifex Stony Plain and Calcrete Plain habitat.

Table 8-4: Land systems mapped within and surrounding the Development Envelope

Land System and associated fauna habitat types	Current extent within the Chichester subregion		Approximate current extent within conservation estate*	Total extent within the Development Envelope		Extent mapped within 20 km buffer of the Development Envelope
	ha	%	%	ha	%	ha
Capricorn – Hillcrest/Hillslope, Gorge/Gully, Rocky Foothills and Breakaway/Cliff	482,779	5.8	44	2,449	0.5	25,158.09
Robe – Hillcrest/Hillslope, Breakaway/Cliff, Rocky Foothills, Spinifex Stony Plain and Calcrete Plain	25,182	0.3	1	214	0.8	-
Rocklea – Rocky Foothills, Spinifex Stony Plain and Calcrete Plain	2,123,354	25.4	42	1,545	0.01	86,909.96
Taylor – Spinifex Stony Plain and Spinifex Sandplain	11,046	0.1	71	257	2.3	4,911.41
TOTAL				**4,465**		

*Approximate extent of occurrence within Ex Meentheena Nature Reserve and Mungaroona Range Nature Reserve. Estimates of land systems within conservation estate were approximated by calculating the total area of each land system within the National Reserve System using the collaborative Australian Protected Area Database (CAPAD) (DAWE 2020).

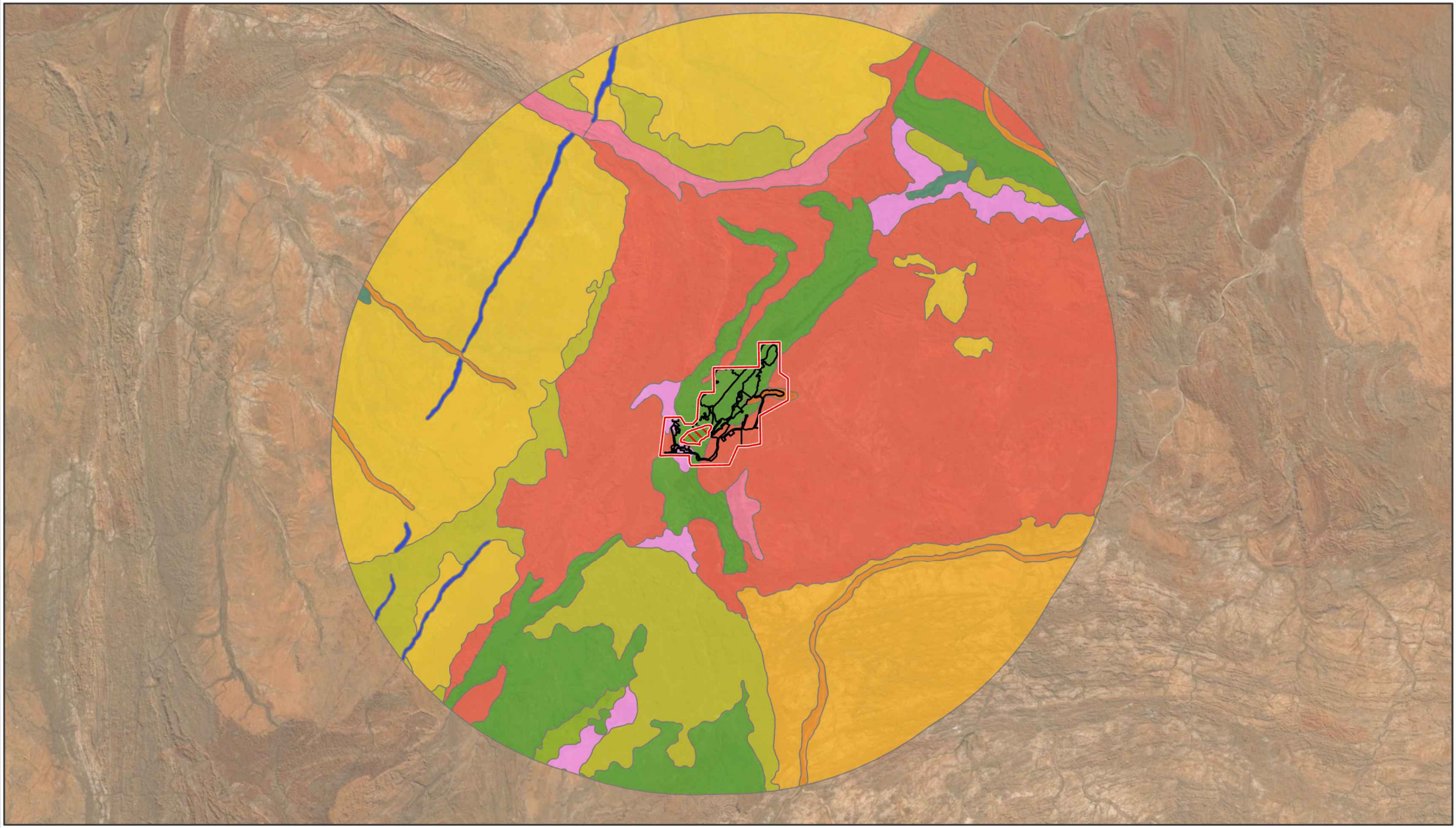

Figure 8-6: Regional extent of land systems within and adjacent to the Development Envelope

Development Envelope
Significant Fauna Exclusion Zone
Conceptual Footprint

Land System

Black System
Boolaloo System
Calcrete System
Capricorn System
Divide System
Granitic System
Macroy System
Mosquito System
River System
Robe System
Rocklea System
Talga System
Taylor System

0 3.5 7 14
Kilometres

Datum/Projection:
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Project: 15064-DD Date: 13/04/2022

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In addition to the broader terrestrial fauna habitat types, several significant habitat features are identified within the Development Envelope, including caves and pools.

Caves are important features that provide shelter, stable microclimates and protection. A total of 20 caves (including deep, shallow and overhangs) have been recorded within the Development Envelope (Figure 8-7). A further six caves have been identified outside of the Development Envelope, one of which is located within the SFEZ.

Caves provide high value roosting habitat for conservation significant fauna, including Ghost Bat and Pilbara Leaf-nosed Bat. These MNES species are discussed in Section 12.

8.3.2.2 Surface Water Pools

Surface water pools generally represent areas of high ecological productivity, particularly in arid environments, and support the survival of species that require continuous access to food and moisture. Fifteen surface water pools have been recorded within the Development Envelope (Biologic 2020b), including five permanent, two semi-permanent and eight temporary/seasonal pools (Table 8-5 and Figure 8-8).

Another five surface water pools are located within the SFEZ (one permanent, one semi-permanent and three temporary/seasonal surface water pools). A further 23 surface water pools have been recorded outside the Development Envelope and SFEZ, along McPhee Creek, Branch of McPhee Creek and Lionel Creek to the south-east, in addition to the two long-term reference sites (Garden Pool and Daylight Pool). It is likely that additional temporary/seasonal water features occur throughout parts of the Development Envelope where pooling occurs after significant rainfall (Biologic 2020b).

An aquatic survey (Biologic 2020a) of surface water pools within McPhee Creek, Branch of McPhee Creek and Lionel Creek, located outside of the Development Envelope, reported high-quality in-stream habitat at the majority of surface water pools assessed, including complex heterogeneous substrates, such as submerged macrophytes, emergent macrophytes, large woody debris, root mats and trailing vegetation. Water quality and Aquatic Fauna are discussed in Section 6.

Table 8-5: Surface water pools recorded in and near to the Development Envelope

Pool identification	Alternative pool identification*	Located within Development Envelope	Approximate distance from Development Envelope	Creekline location	Permanence
McPhee Creek					
McPC2		No	10 km	McPhee Creek	Permanent
VMPC-78	McPC3	No	13.5 km	McPhee Creek	Semi-permanent
VMPC-79		No	15.9 km	McPhee Creek	Permanent
WMPC-10		No	9.1 km	McPhee Creek	Temporary/seasonal
WMPC-11		No	9.3 km	McPhee Creek	Temporary/seasonal
WMPC-12		No	9.5 km	McPhee Creek	Semi-permanent
WMPC-13		No	9.7 km	McPhee Creek	Temporary/seasonal
WMPC-14		No	9.9 km	McPhee Creek	Temporary/seasonal
WMPC-15		No	10.0 km	McPhee Creek	Permanent
WMPC-16		No	10.7 km	McPhee Creek	Temporary/seasonal
WMPC-17		No	11.1 km	McPhee Creek	Temporary/seasonal
Lionel Creek					
UN1		No	9.3 km	Lionel Creek	Temporary/seasonal
UN2		No	10.5 km	Lionel Creek	Temporary/seasonal
VMPC-80	UN4	No	11.8 km	Lionel Creek	Temporary/seasonal
VMPC-81	UN3	No	11.3 km	Lionel Creek	Permanent
Branch of McPhee Creek					
VMPC-77	BMcPC1	No	2.1 km	Branch of McPhee Creek	Temporary/seasonal

Pool identification	Alternative pool identification*	Located within Development Envelope	Approximate distance from Development Envelope	Creekline location	Permanence
VMPC-82	BMcPC4	No	8.8 km	Branch of McPhee Creek	Temporary/seasonal
VMPC-83	BMcPC3	No	8.5 km	Branch of McPhee Creek	Semi-permanent
VMPC-84	BMcPC2	No	6.0 km	Branch of McPhee Creek	Semi-permanent
Range Pools					
WMPC-01		Yes	-	Sandy Creek	Permanent
WMPC-02		Yes	-	Sandy Creek	Temporary/seasonal
WMPC-03		Yes	-	Sandy Creek	Permanent
WMPC-04		No	0.016 km	Sandy Creek	Temporary/seasonal
WMPC-05		No	0.016 km	Sandy Creek	Permanent
WMPC-06		No	0.048 km	Sandy Creek	Temporary/seasonal
WMPC-07		No	0.048 km	Sandy Creek	Temporary/seasonal
WMPC-08	Range 1	Yes	-	Sandy Creek	Permanent
WMPC-09	Range 2	Yes	-	Lionel Creek	Permanent
WMPC-18		No, inside SFEZ	Retained within SFEZ	Spinaway Creek	Semi-permanent
WMPC-19		No, inside SFEZ	Retained within SFEZ	Spinaway Creek	Temporary/seasonal
WMPC-20		No, inside SFEZ	Retained within SFEZ	Spinaway Creek	Temporary/seasonal
WMPC-21	Range 3	No, inside SFEZ	Retained within SFEZ	Spinaway Creek	Permanent

Pool identification	Alternative pool identification*	Located within Development Envelope	Approximate distance from Development Envelope	Creekline location	Permanence
WMPC-22		Yes	-	Sandy Creek	Permanent
WMPC-25		Yes	-	Lionel Creek	Semi-permanent
WMPC-26		Yes	-	Lionel Creek	Temporary/seasonal
WMPC-27		Yes	-	Lionel Creek	Semi-permanent
WMPC-28		Yes	-	Sandy Creek	Temporary/seasonal
WMPC-29		Yes	-	Sandy Creek	Temporary/seasonal
WMPC-30		Yes	-	Sandy Creek	Temporary/seasonal
WMPC-31		Yes	-	Lionel Creek	Temporary/seasonal
WMPC-32		No, inside SFEZ	Retained within SFEZ	Sandy Creek	Temporary/seasonal
WMPC-33		Yes	-	Sandy Creek	Temporary/seasonal
WMPC-34		Yes	-	Spinaway Creek	Temporary/seasonal
Long-term reference sites					
Garden Pool		No	-	Nullagine River	Semi-permanent
Daylight Pool		No	-	Nullagine River	Semi-permanent

*Alternative pool references may be used in some Biologic and GHD reports

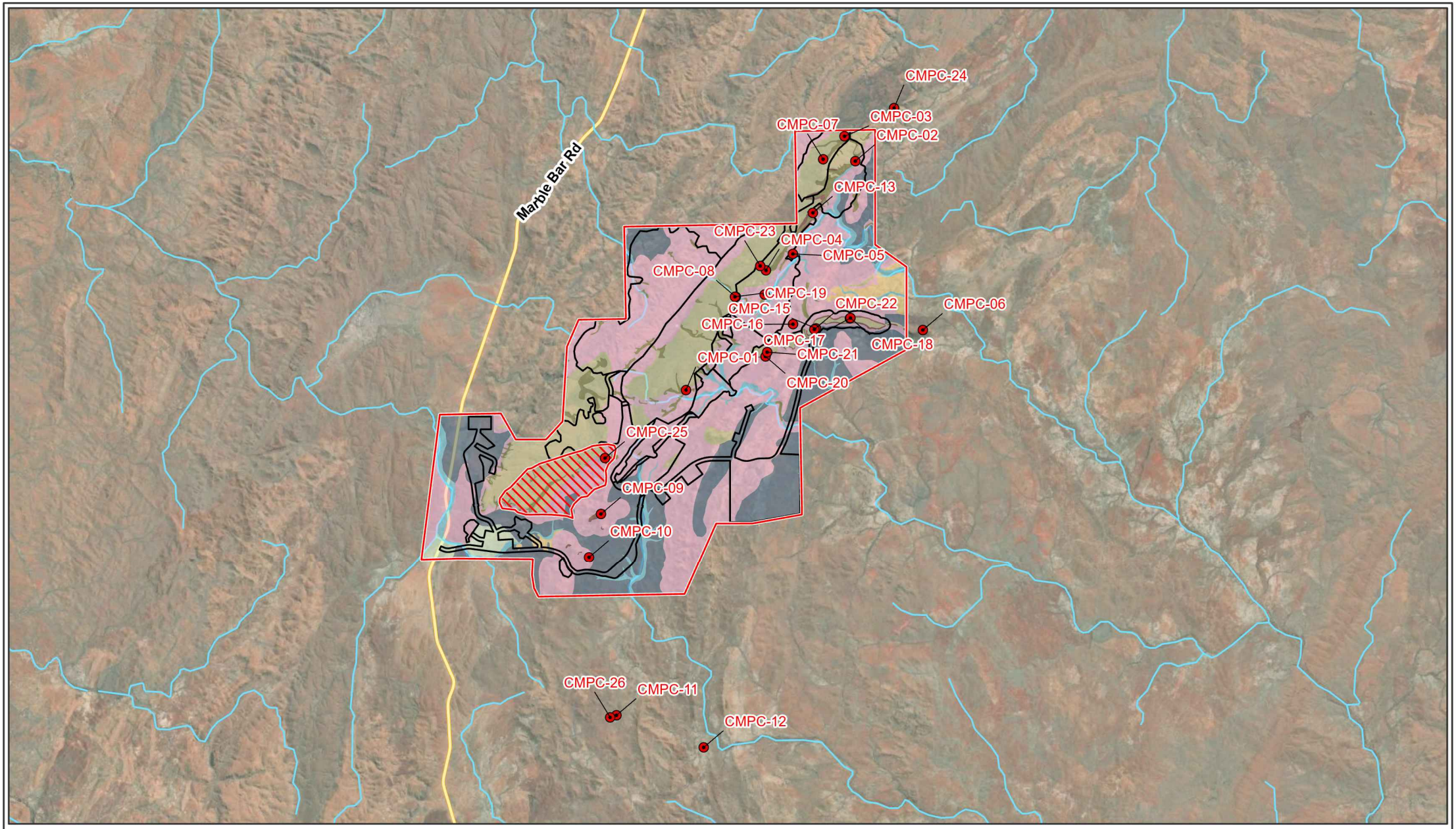

Figure 8-7: Caves recorded in and near to the Development Envelope

- Development Envelope
- Conceptual Footprint
- Significant Fauna Exclusion Zone
- Cave
- Drainage Line

Fauna Habitat Types (Biologic 2021a)

- Breakaway/Cliff
- Calcrete Plain
- Drainage Line
- Gorge/Gully
- Hillcrest/Hillslope
- Rocky Foothills
- Spinifex Sandplain
- Spinifex Stony Plain

0 0.75 1.5 3
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 13/04/2022

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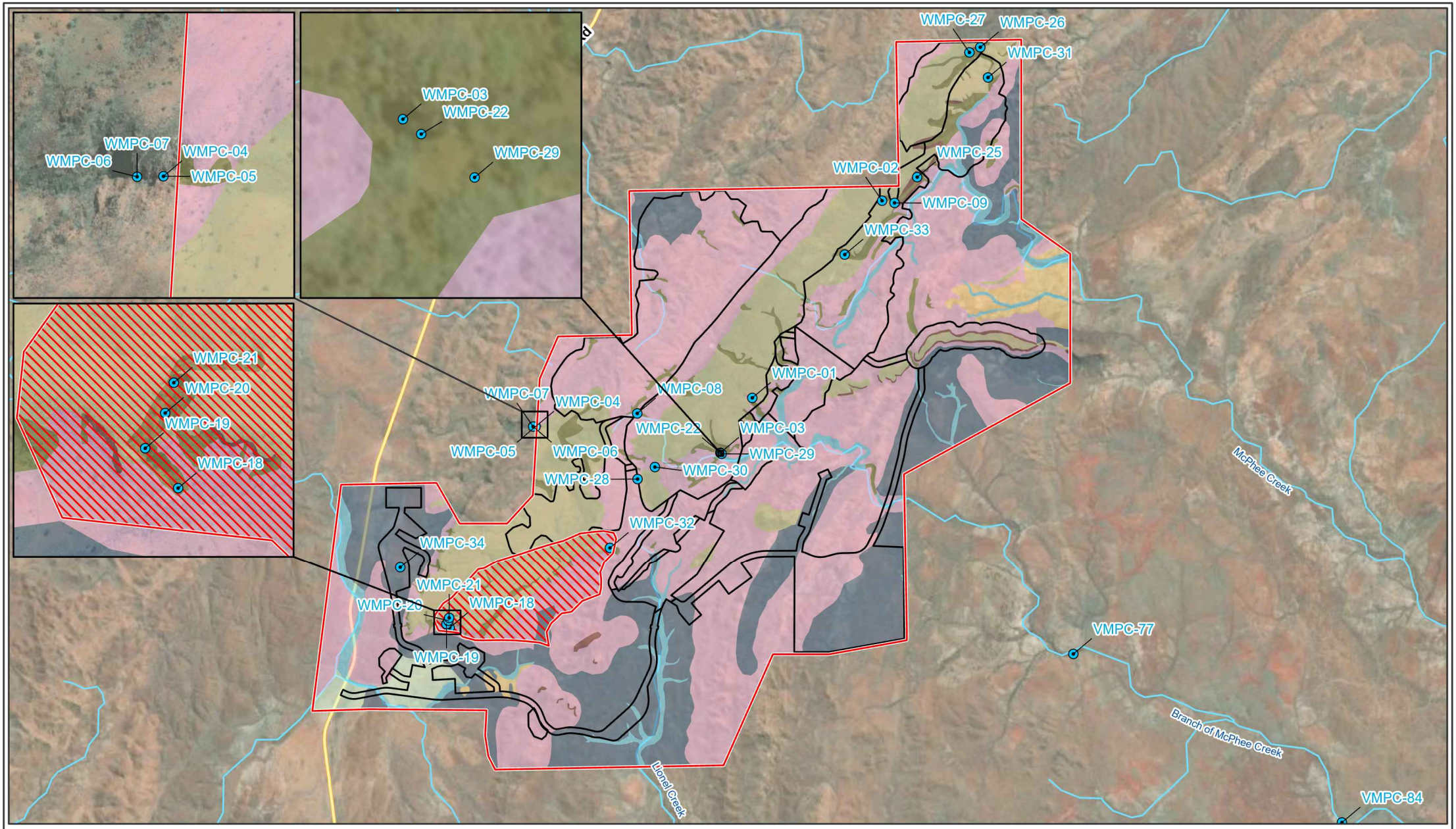

Figure 8-8: Surface water pools recorded in and near to the Development Envelope

- Development Envelope
- Conceptual Footprint
- Significant Fauna Exclusion Zone
- Pool
- Drainage Line

Fauna Habitat Types (Biologic 2021a)

- Breakaway/Cliff
- Calcrete Plain
- Drainage Line
- Gorge/Gully
- Hillcrest/Hillslope
- Rocky Foothills
- Spinifex Sandplain
- Spinifex Stony Plain

0 0.5 1 2
Kilometres

Datum/Projection:
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8.3.3 Species diversity and fauna assemblage

A total of 44 vertebrate fauna species were recorded during the 2020 terrestrial fauna survey (Biologic 2020b), including nine mammals, 33 bird species, one reptile and one amphibian species. All species have been recorded during previous survey efforts.

A further 120 species have been recorded during previous surveys, giving a total of 164 species, comprising 31 mammals, 70 birds, 60 reptiles and three amphibians across all survey effort.

8.3.3.1 Mammals

Of the 31 mammal species recorded, bats were the most abundant group, with ten species identified, followed by Dasyurids (six species) and rodents (five species). Six mammals of conservation significance and five introduced species have been recorded in the Development Envelope (Cat, Dog, Cattle, Horse and House Mouse) (Biologic 2020b; MWH 2014abc; Outback Ecology 2012ab, 2013c and 2014b).

8.3.3.2 Birds

Of the 70 bird species recorded, the Meliphagidea family (honeyeaters and allies) were the most abundant and diverse with nine species recorded. The most common species recorded was the Budgerigar (*Melopsittacus undulatus*). No conservation significant bird species were recorded during the 2020 survey (Biologic 2020b); however, the Fork-tailed Swift (*Apus pacificus*) was recorded during a previous survey (Outback Ecology 2014b).

8.3.3.3 Reptiles

Of the 60 reptile species recorded in the 2020 and previous surveys, skinks were the most abundant group representing 18 species, followed by Diplodactylid geckos (eight), Elapids (venomous snakes) (seven), and Varanids (Monitors) (six). The most common and widespread reptile recorded was the Stony-soil Ctenotus (*Ctenotus inornatus*).

One conservation significant reptile species, the Pilbara Olive Python (*Liasis olivaceus barroni*) has been recorded from the 2020 and previous surveys (Biologic 2020b; Outback Ecology 2012b).

8.3.3.4 Amphibians

Three amphibian species have been recorded across the 2020 and previous terrestrial fauna surveys (Biologic 2020b; Outback Ecology 2012b). These include *Litoria rubella*, *Cyclorana maini* and *Uperoleia saxatillis*. No conservation significant amphibian species have been recorded.

8.3.3.5 Aquatic invertebrates and Fish

Aquatic invertebrates and fish are discussed in the Inland Waters Chapter (Section 6).

8.3.4 Conservation significant fauna

A total of eight species of conservation significance have been recorded from the 2020 survey and previous surveys (Biologic 2020b; Outback Ecology 2012b), including Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Greater Bilby, Pilbara Olive Python, Long-tailed Dunnart, Western Pebble-mound Mouse and Fork-tailed Swift. One further species, Gane's Blind Snake, is considered highly likely to occur, Grey Falcon is considered likely and six additional conservation significant species may possibly occur. While considered unlikely to occur within the Development Envelope, Night Parrot has also been assessed given its status as Endangered under the EPBC Act and Critically Endangered under the BC Act. Table 8-6 identifies species

known or considered likely or possible to occur in the Development Envelope. Figure 8-9 shows the location of records of conservation significant fauna species within the Development Envelope.

A further 22 species were identified by desktop assessment as having the potential to occur; however, based on an assessment of habitat requirements and habitat availability, these species were subsequently considered unlikely to occur (Biologic 2021a). Nine of the conservation significant species confirmed or likely to occur within the Development Envelope are MNES protected under the EPBC Act. This includes Northern Quoll, Night Parrot, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python, Greater Bilby, Northern Brush Tailed Possum, Fork-tailed Swift and Grey Falcon, and these species are discussed in Section 12. Those conservation significant species likely to occur and not protected under the EPBC are discussed below.

8.3.4.1 Long-tailed Dunnart (Sminthopsis longicaudata)

Within Western Australia, the Long-tailed Dunnart is distributed from Morawa to the Northern Pilbara and to the Gibson Desert in the east (Biologic 2021a). The species is not endemic to WA and is known to persist through the McDonnell Ranges in the Northern Territory (WAMC 2021). The species is considered to be limited to rocky habitats with limited vegetation, or to open woodland, shrubs or spinifex hummock grassland. Within the Development Envelope, suitable habitat for the Long-tailed Dunnart consists of the Hillcrest/Hillslope and Breakaway/Cliff habitat types, both of which are widespread throughout the Pilbara region.

8.3.4.2 Western Pebble-mound Mouse (Pseudomys chapmani)

The Western-Pebble-mound Mouse is distributed from the Gibson Desert to the east through the Great Sandy Desert's eastern edge and is endemic to the Pilbara region (Biologic 2021a). Within the Development Envelope, the Rocky Foothills, Calcrete Plain, Hillcrest/Hillslopes and Spinifex stony Plain habitat types are expected to be suitable for the species, given its almost exclusive distribution on rocky ranges and low undulating hills with spinifex and scattered shrubs.

8.3.4.3 Gane's Blind Snake (Anilios ganei)

The Gane's Blind Snake is endemic to the Pilbara region and typically occurs within moist gullies and gorges (Biologic 2021a). Within the Development Envelope, these habitat preferences are represented within the Gorge/Gully and Drainage Line habitat types.

Table 8-6: Conservation significant fauna species known, likely or possible to occur

Species	Conservation status[1]	Habitat	Records from the Development Envelope and ALA regional records	Likelihood of occurrence
Mammals				
Northern Quoll *Dasyurus hallucatus*	Endangered – EPBC Act, BC Act	Denning/breeding and foraging habitat: Gorge/Gully and Breakaway/Cliff. Foraging and dispersal habitat: Drainage Line, Hillcrest/Hillslope and Rocky Foothills.	Recorded from recent 2020 (Biologic 2020b) and previous surveys (MWH 2014b, Outback Ecology 2012b and 2012a). 9,252 records across Australia, with 501 occurring in WA (ALA 2022). There are 106 location records within the Pilbara, of which 64 are within the Chichester subregion.	**Confirmed**
Pilbara Leaf-nosed Bat *Rhinonicteris aurantia*	Vulnerable – EPBC Act, BC Act	Roosting and foraging habitat: Gorge/Gully and Breakaway/Cliff. Foraging and dispersal habitat: Drainage Line, Hillcrest/Hillslope and Rocky Foothills.	Recorded from recent 2020 (Biologic 2020b) and previous surveys (MWH 2014c, Outback Ecology 2012b and 2013c).	**Confirmed**
Ghost Bat *Macroderma gigas*	Vulnerable – EPBC Act, BC Act	Roosting and foraging habitat: Gorge/Gully and Breakaway/Cliff. Foraging and dispersal habitat: Drainage Line, Hillcrest/Hillslope and Rocky Foothills.	Recorded from 2020 (Biologic 2020b) and previous surveys (MWH 2014c, Outback Ecology 2012band 2013c). 846 records across Australia, with 138 records in WA (ALA 2022). 91 of these records occur within the Chichester subregion, with 103 location records in the broader Pilbara region.	**Confirmed**
Greater Bilby *Macrotis lagotis*	Vulnerable – EPBC Act, BC Act.	Breeding/shelter, foraging and dispersal habitat: Spinifex Sandplain.	Not recorded in 2020 survey. Recorded from previous surveys (MWH 2014a, Outback Ecology 2012b and 2014b). 48,751 location records across Australia, 177 of which are in Western Australia (ALA 2022). Eight of these records occur in the Pilbara region.	**Previously confirmed**

Species	Conservation status[1]	Habitat	Records from the Development Envelope and ALA regional records	Likelihood of occurrence
Long-tailed Dunnart *Sminthopsis longicaudata*	Priority 4 - WA	Breeding/shelter, foraging and dispersal habitat: Gorge/Gully, Breakaway/Cliff and Hillcrest/Hillslope. Marginal breeding/shelter habitat: Rocky Foothills.	Not recorded in 2020 survey. Recorded in 2012 (Outback Ecology 2012b).	**Previously confirmed**
			72 location records occurring across Australia, with 50 in Western Australia and 22 in the Northern Territory (ALA 2022). There are 22 records of the species from the Pilbara region, which includes 6 from the Chichester subregion.	
Western Pebble-mound Mouse *Pseudomys chapmani*	Priority 4 - WA	Breeding/shelter, foraging and dispersal habitat: Calcrete Plain, Spinifex Stony Plain. Marginal breeding/shelter habitat: Rocky Foothills.	Not recorded in 2020 survey. Recorded in 2012 (Outback Ecology 2012b) and 2014b.	**Previously confirmed**
			220 location records of the species all of which occur in Western Australia (ALA 2022). 191 of these are from the Pilbara region, with 65 from the Chichester subregion.	
Northern Brushtail Possum *Trichosurus vulpecula arnhemensis*	Vulnerable – EPBC Act, BC Act	Breeding/shelter, foraging and dispersal habitat: Gorge/Gully and Drainage line.	No records.	Possible
			9,731 records across Australia, of which the majority (9,666) are from the Northern Territory, with 62 in Western Australia (ALA 2022). 9 of these are within the Pilbara region.	
Spectacled Hare Wallaby *Lagorchestes conspicillatus leichardti*	Priority 3 - WA	Breeding/shelter, foraging and dispersal habitat: Spinifex Sandplain and Spinifex Stony Plain.	No records from Development Envelope.	Possible
			23 records within Western Australia and an additional 11 records from Queensland (ALA 2022). 10 records are located within the Pilbara region, all of which occur in the Chichester subregion.	

Species	Conservation status[1]	Habitat	Records from the Development Envelope and ALA regional records	Likelihood of occurrence
Brush-tailed Mulgara *Dasycercus blythi*	Priority 4 - WA	Breeding/shelter, foraging and dispersal habitat: Spinifex Sandplain.	No records from Development Envelope. 1,393 records from across Australia, 100 of which occur within Western Australia and the majority (1,270) are from the Northern Territory (ALA 2022). There are 14 location records from the Pilbara region, with 11 occurring in the Chichester subregion.	Possible
Birds				
Fork-tailed Swift *Apus pacificus*	Migratory - EPBC Act, BC Act	All habitats.	Not recorded in 2020 survey. Recorded in 2014 (Outback Ecology 2014b). 10,983 records across all States/Territories of Australia (ALA 2022). 904 of these records occur in Western Australia, with 33 in the Pilbara region.	**Previously confirmed** Transient
Grey Falcon *Falco hypoleucos*	Vulnerable – EPBC Act, BC Act	Breeding/shelter, foraging/dispersal habitat: Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope and Drainage Line.	No records from Development Envelope. 2,964 records across Australia, with 224 in Western Australia (ALA 2022). 61 of these records are from the Pilbara region, including 47 from the Chichester subregion.	Likely
Peregrine Falcon *Falco peregrinus*	Other specially protected fauna – BC Act	Breeding/roosting, foraging and dispersal habitat: Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope and Drainage Line.	No records from Development Envelope. 45,554 records across Australia including 2,688 from Western Australia (ALA 2022). There are 8 records which occur in the Chichester subregion, with a total of 79 records in the broader Pilbara region.	Possible

Species	Conservation status[1]	Habitat	Records from the Development Envelope and ALA regional records	Likelihood of occurrence
Reptiles				
Pilbara Olive Python *Liasis olivaceus barroni*	Vulnerable – EPBC Act, BC Act	Breeding/shelter and hunting/foraging, Gorge/Gully and Breakaway/Cliff. Foraging and dispersal: Drainage Line, Hillcrest/Hillslope.	Recorded from 2020 survey (Biologic 2020b) and previous survey (Outback Ecology 2012b).	**Confirmed**
			There are 34 records of this species in Australia, 33 of which occur in the Pilbara region and one additional record in the Gascoyne region of Western Australia (ALA 2022). Ten of these location records occur within the Chichester subregion.	
Gane's Blind Snake *Anilios ganei*	Priority 1 – WA	Breeding/shelter, foraging and dispersal habitat: Gorge/Gully. Foraging and dispersal habitat: Drainage Line.	No records from Development Envelope.	Highly likely
			There are 23 records of this species in Australia, all of which occur within the Pilbara region of Western Australia (ALA 2022). Five of these records are from the Chichester subregion.	
Black-lined Ctenotus (Pin-striped fine snout) *Ctenotus nigrilineatus*	Priority 1 - WA	Marginal habitat: Spinifex Stony Plain, Rocky Foothills and Drainage Line.	No records from Development Envelope.	Possible
			There are 19 records of this species within Australia, all of which occur in the Pilbara region of Western Australia (ALA 2022). 18 of these records are from the Chichester subregion, with one record occurring in the Hamersley subregion.	
Spotted Ctenotus *Ctenotus uber* subsp. *johnstonei*	Priority 2 - WA	Marginal breeding/shelter habitat: Spinifex Stony Plain, Rocky Foothills and Hillcrest/Hillslope.	No records from Development Envelope.	Possible
			There are 16 total records of this species, all of which are from Western Australia (ALA 2022). Three of these records occur within the Pilbara region.	

1 – Conservation status definitions are described in (Biologic 2021a)

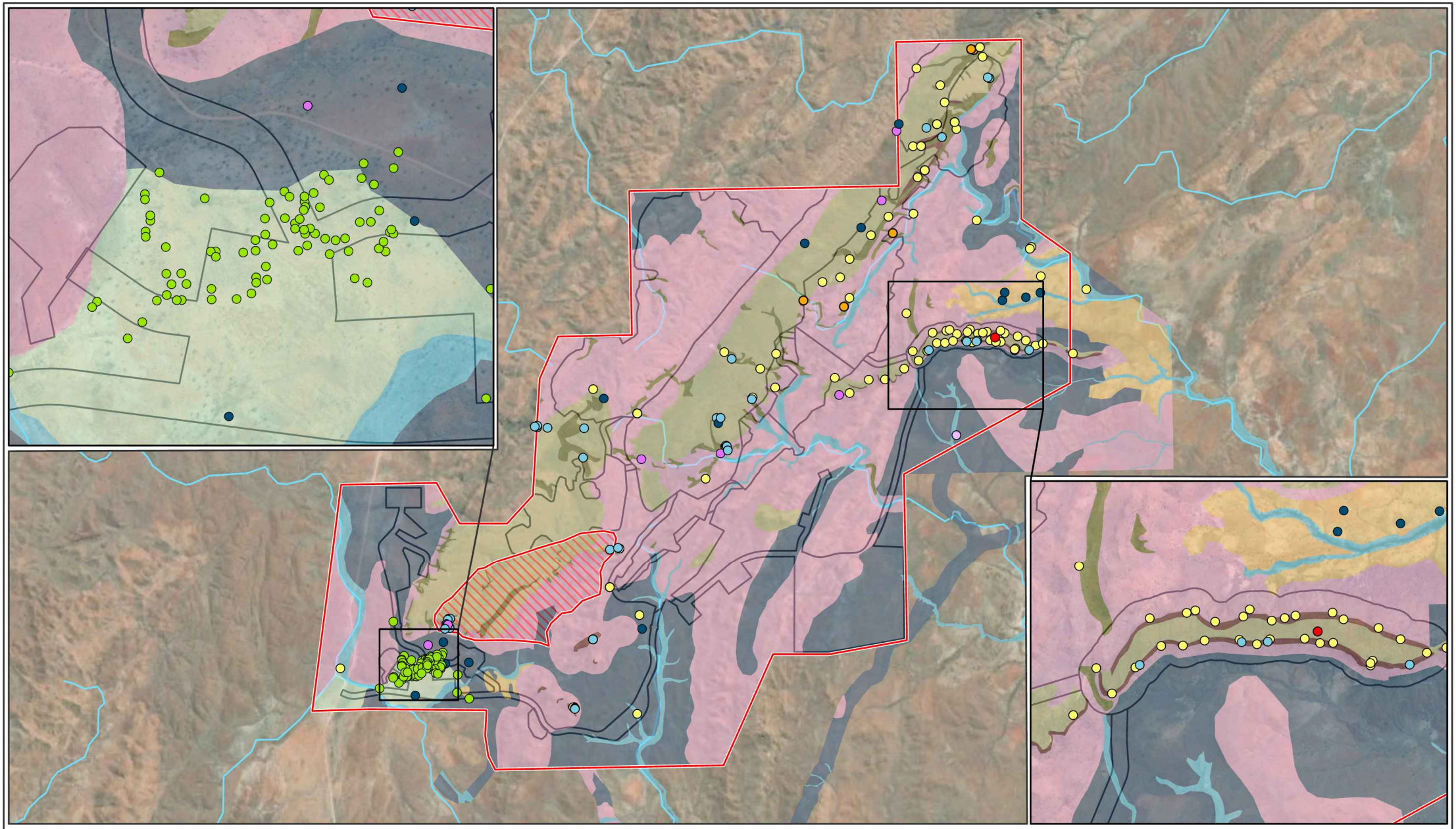

Figure 8-9: Conservation significant fauna records within and adjacent to the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone

Conservation significant fauna

- Northern Quoll (*Dasyurus hallucatus*) - EN
- Pilbara Olive Python (*Liasis olivaceus barroni*) - VU
- Ghost Bat (*Macroderma gigas*) - VU
- Greater Bilby (*Macrotis lagotis*) - VU
- Pilbara leaf-nosed bat (*Rhinonicteris aurantia*) - VU
- Western Pebble-mound Mouse (*Pseudomys chapmani*) - P4
- Long-tailed Dunnart (*Sminthopsis longicaudata*) - P4
- Fork-tailed swift (*Apus pacificus*) - MI

0 0.5 1 2
Kilometres

Datum/Projection:
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8.3.5 Short range endemics

SRE invertebrate fauna are defined as surface dwelling invertebrates that, as a result of evolutionary isolation, have naturally small distributions (below 10,000 km^2) and are often characterised by low fecundity, poor dispersal capabilities and highly specific habitat preferences or confinement to discontinuous habitats (EPA 2016g). Some better-known SRE species have been listed under State or Commonwealth legislation or as Priority species by the DBCA; however, given the lack of taxonomic knowledge, the majority of SRE species have not been listed under any legislation. In the absence of formal listings, invertebrate fauna taxa can be assigned an SRE status category: Confirmed SRE, Potential SRE or widespread (i.e. not an SRE). This categorisation indicates the potential for range restriction and thus informal conservation significance (EPA 2016g; Biologic 2019b).

The SRE status categories used within this ERD broadly follow the Western Australia Museum's (WAM's) revised categorisation for SRE invertebrates. This system is based upon the 10,000 km^2 range criterion proposed by taxonomic experts (Harvey et. al. 2002) and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 8-7).

Table 8-7: SRE categorisation used by WAM taxonomists

Taxonomic certainty		Taxonomic uncertainty
Distribution <10,000 km^2	**Confirmed SRE** • a known distribution of <10,000 km^2 • taxonomy well known • group is well represented in collections and/or via comprehensive sampling.	**Potential SRE** • patchy sampling resulting in incomplete knowledge of geographic distribution • incomplete taxonomic knowledge • group not well represented in collections • category applies where there are significant knowledge gaps SRE sub-categories may apply: • data deficient • habitat indicators • morphology indicators • molecular evidence • research and expertise
Distribution >10,000 km^2	**Widespread (not an SRE)** • a known distribution of >10,000 km^2 • taxonomy well known • group is well represented in collections and/or via comprehensive sampling.	

Source: Biologic 2019b)

To date, two targeted SRE field surveys have been conducted for the Proposal, including a wet season survey in 2012 (Outback Ecology 2013b) and a dry season survey in 2019 (Biologic 2019b). Since the 2012 survey, the Proposal design has been substantially revised; however, both surveys cover the entire Development Envelope.

Both surveys were undertaken in accordance with the EPA Technical Guidance for SREs (EPA 2016g) and included a range of sampling techniques including wet pitfall trapping (2012 survey

only), active foraging, leaf litter and soil sifting, and targeted searches for spider and scorpion burrows (Outback Ecology 2013b) and Biologic 2019b).

In addition to the targeted SRE surveys, an aquatic fauna survey was also conducted in 2020 (Biologic 2020a). This survey sampled invertebrates in the hyporheos zone of several surface water pools along McPhee Creek, Branch of McPhee Creek and Lionel Creek, outside of the Development Envelope. SRE invertebrates were recorded during this survey; however, these species are discussed in the aquatic fauna section (refer to Section 6).

8.3.5.1 SRE invertebrate fauna habitats

Habitat assessments undertaken in 2019 identified six SRE habitat types within four habitat zones within the Development Envelope (Biologic 2020f; Table 8-8 and Figure 8-10).

Of the habitats mapped, the Gorge/Gully habitat has a high suitability for SRE invertebrate fauna as it contains complex rocky microhabitats and patches of dense vegetation that provide high protection and isolated habitats favoured by SRE invertebrate fauna (Biologic 2020e). This habitat type is not restricted and extends beyond the Development Envelope.

The Breakaway/Cliff habitat provide medium or medium to low suitability for SRE invertebrate fauna due to moderate/high levels of shade and shelter, and some degree of isolation but are often more exposed than the Gorge/Gully habitat type, and with less complex microhabitats (Biologic 2020f). None of these habitats are restricted and all extend beyond the Development Envelope.

The Hillcrest/Hillslope and Medium Drainage Line habitats provide low to moderate value for SRE invertebrate fauna as they generally provide some shelter and shade (but less than high value habitats), but are more widespread and not isolated, and in the case of the Drainage Lines, are occasionally flooded making them less suitable for SREs.

The remaining habitat types have low suitability for SRE invertebrate fauna as they lack shade or shelter, do not contain complex microhabitats, and are generally not isolated (Biologic 2020f). Low value habitats are not discussed further.

Table 8-8: Habitat zones and suitability for SRE mapped during dry season survey

Habitat zone	SRE habitat types	Description	Suitability for SRE
Rocky crests and slopes	Gorge/Gully	Rocky landforms usually offering moderate to moderate/high levels of shade and shelter, complex rocky microhabitats, and patches of dense vegetation. Suitability for SRE fauna can be high due to high protection and high isolation.	High
	Breakaway/Cliff	Rocky/mountainous habitats featuring extensive breakaway/rock face. This habitat type can generally provide moderate/high levels of shade and shelter, complex rocky microhabitats and some degree of isolation. Often more exposed than gorge/gullies and hence only moderately suitable for SRE fauna.	Moderate

Habitat zone	SRE habitat types	Description	Suitability for SRE
	Hillcrest/Upper Hillslope	Open (exposed) habitats on the slopes or tops of high hills and mountains that are not highly complex and generally sparsely vegetated. These areas may be isolated, but unless there is another landform or vegetation feature providing a protected microhabitat are usually considered of low to moderate suitability for SRE fauna.	Low to moderate
Drainage areas	Medium Drainage Line	Drainage areas that can be densely vegetated, and extensive, but tend to be prone to disturbances from flooding. May provide dispersal opportunities for some SRE invertebrate fauna. Isolation tends to be low as drainage lines are highly interconnected.	Low to moderate
Rounded hills	Undulating Low hills	May contain small rocky outcrops or dense vegetation thickets, but unlikely to support SRE species due to high exposure, low complexity, and low isolation.	Low
Plains	Sandy/ Stony Plain	Mostly flat, extensive, open areas that may feature pockets of shrubland or open woodland and limited detrital microhabitats, however, are unlikely to support SRE species due to high exposure, low complexity, and low isolation	Low

Source: Biologic 2020e

8.3.5.2 SRE invertebrate fauna records

Over 439 invertebrate specimens from groups that contain known SREs have been collected within the Development Envelope during previous surveys (Biologic 2019a; Outback Ecology 2013b). Of these, three species are considered to represent confirmed SREs and 13 are considered to represent potential SREs (Table 8-9; Biologic 2019a; Outback Ecology 2013b). The species recorded within the current Development Envelope are described below in Table 8-9 and locations of these records are depicted in Figure 8-10.

Table 8-9: Summary of confirmed and potential SRE within the Development Envelope

Order /taxa	SRE status	Survey	Location in relation to Conceptual Footprint		Habitat species recorded in	Additional information
			Inside	Outside		
Polydesmida (Millipede)						
Antichiropus cunicularis n. sp. 'DIP026'	Confirmed	Outback Ecology (2013b)	✓	✓	Gorge/Gully Undulating Low Hills Medium Drainage Line	Taxon was recently described in taxonomic literature (Car et al., 2019 cited in Biologic 2019b). Eight specimens recorded from four locations. This genus is diverse, and most species are known SREs.
Paradoxosomatidae sp. indet	Potential	Biologic (2019b)	✓	-	Breakaway/Cliff	One specimen collected. The specimen could not be identified further due to its poor condition.
Pseudoscorpiones (Pseudoscorpion)						
Austrohorus' AES03'	Potential	Biologic (2019b)	✓	✓	Gorge/Gully Hillcrest/ Upper Hillslope Medium Drainage Line Breakaway/Cliff	A total of 18 specimens (nine males, seven females and two juveniles) were collected from 11 sites.
Beierolpium' sp. 8/4 lge'	Potential	Outback Ecology (2013b)	-	✓	Medium Drainage Line	One specimen collected. Due to poor taxonomic resolution, the specimen could not be compared to regional records; however, it is considered to have the potential to represent an SRE.

Order /taxa	SRE status	Survey	Location in relation to Conceptual Footprint		Habitat species recorded in	Additional information
			Inside	Outside		
Euryolpium sp. indet.	Potential	Biologic (2019b)	✓	-	Breakaway/ Cliff	One specimen was collected. Due to the juvenile status of the specimen, it could not be identified further.
Genus' 7/4' sp. nov.	Potential	Outback Ecology (2013b)	✓	-	Undulating Low Hills	One specimen was collected. Due to poor taxonomic resolution, the specimen could not be compared to regional records; however, it is considered to have potential to represent an SRE.
Indolpium' AES01'	Potential	Biologic (2019b)	✓	✓	Gorge/Gully Breakaway/ Cliff Hillcrest/ Upper Hillslope Medium Drainage Line	A total of 23 specimens (11 males, 11 females and one juvenile) of this undescribed species were collected from eight sites.
Indolpium' AES02'	Potential	Biologic (2019b)	✓	-	Sandy/Stony Plain	One female specimen collected.
Indolpium' AES03'	Potential	Biologic (2019b)	✓	-	Hillcrest/Upper Hillslope Medium Drainage Line Undulating Low Hills Sandy/Stony Plain	A total of 11 specimens (five males, four females and two juveniles) of this undescribed species were collected from four sites.
Olpiidae gen. nov.	Potential	Biologic (2019b)	✓		Breakaway/ Cliff	One specimen collected, possibly represents a new genus for the Pilbara. There is currently insufficient information to confirm the SRE status of this specimen.

Order /taxa	SRE status	Survey	Location in relation to Conceptual Footprint		Habitat species recorded in	Additional information
			Inside	Outside		
Xenolpium' PSE063'	Potential	Outback Ecology (2013b)	✓	✓	Gorge/Gully Medium Drainage Line	A total of 29 specimens collected from ten sites. At the time of the survey, this species was only known to occur in the study area and was therefore considered an SRE species.
Araneae (Spider)						
Idiopidae sp. indet	Potential	Biologic (2019b)	✓	-	Breakaway/Cliff	A single juvenile was collected Given the juvenile status of the specimen, it could only be identified to family *Idiopidae* sp. indet, which is known to contain potential SRE species.
Scorpiones (Scorpions)						
Buthidae sp. indet.	Potential	Biologic (2019b)	-	✓	Gorge/Gully in SFEZ	One buthid exuviae (shed exoskeleton) was collected. Further identification of the specimen was not possible due being an exuviae.
Isopoda (Woodlouse)						
Armadillidae sp. indet	Potential	Biologic (2019b)	-	✓	Gorge/Gully in SFEZ	One specimen was collected The specimen could not be further identified due to being in poor condition.

Order /taxa	SRE status	Survey	Location in relation to Conceptual Footprint		Habitat species recorded in	Additional information
			Inside	Outside		
Buddelundia sp. 11	Confirmed	Outback Ecology (2013b)	✓	✓	Breakaway/ Cliff Medium Drainage Line Gorge/Gully Hillcrest/ Upper Hillslope Sandy/Stony Plain	A total of 46 specimens were collected from ten sites. This species is also known to occur regionally from previous surveys; however, its distribution is less than 10,000 km^2 and it is therefore considered a confirmed SRE.
Buddelundia sp. 18	Confirmed	Outback Ecology (2013b)	✓	✓	Breakaway/ Cliff Gorge/Gully Hillcrest/ Upper Hillslope Undulating Low Hills Sandy/Stony Plain	A total of 56 specimens were collected from 13 sites. This species is known to occur regionally from previous surveys; however, its distribution is less than 10,000 km^2 and it is therefore considered a confirmed SRE.

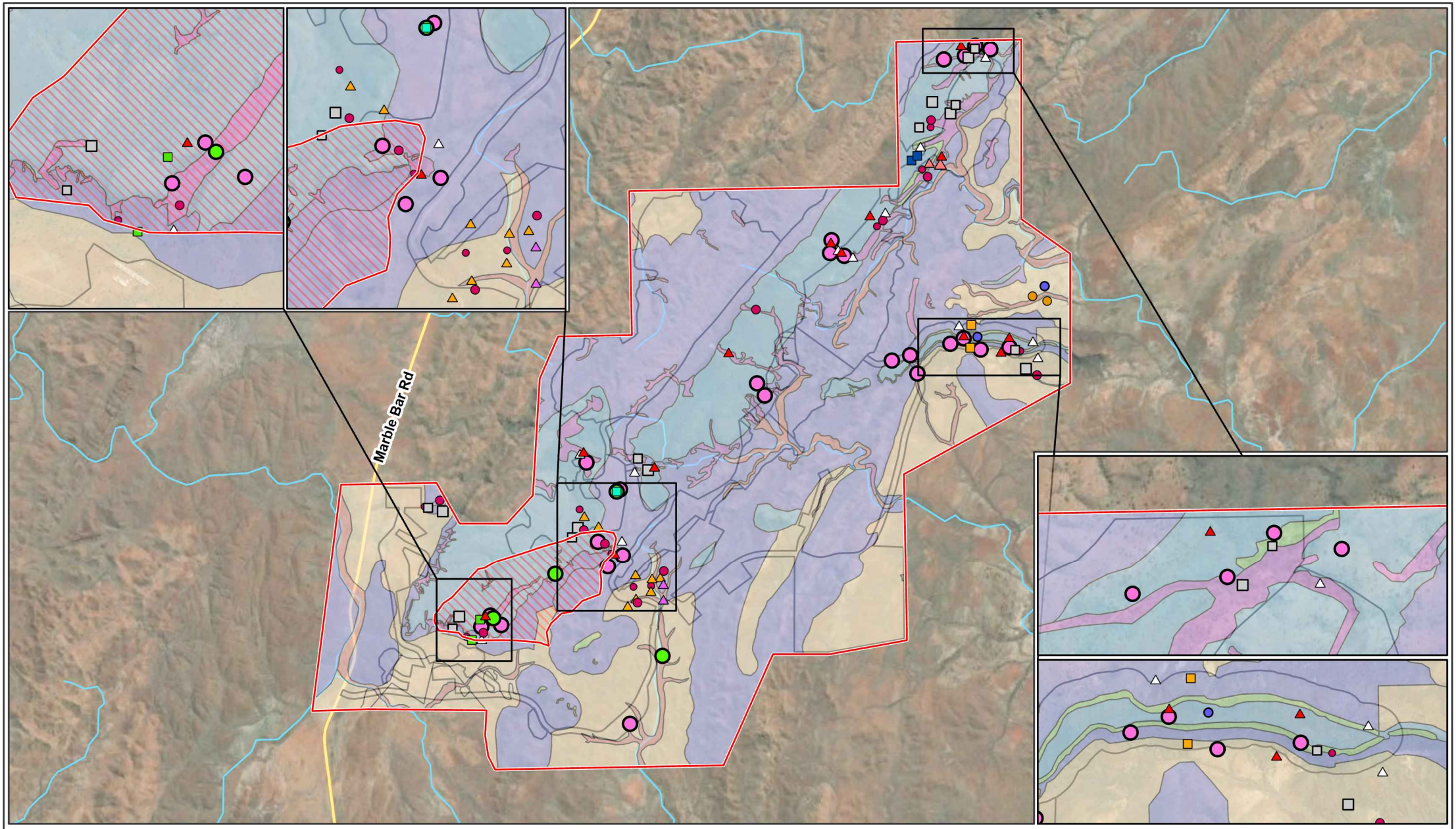

Figure 8-10: SRE habitat and records within the Development Envelope

Development Envelope
Conceptual Footprint
Significant Fauna Exclusion Zone

Confirmed SRE Taxa

Antichiropus `DIP026`
Buddelundia sp. nov. 18

Potential SRE Taxa (Biologic 2020e)

Armadillidae sp. indet.
Austrohorus sp. 'AES03'
Beierolpium sp. '8/4 lge'
Buthidae sp. indet.
Euryolpium sp. indet.
'Genus 7/4' sp.
Idiopidae sp. indet.
Indolpium sp. 'AES01'
Indolpium sp. 'AES02'
Indolpium sp. 'AES03'
Olpiidae gen. nov.
Paradoxosomatidae sp. indet.
Xenolpium sp. 'PSE063'

Fauna Habitat Types (Biologic 2020j)

Breakaway/ Cliff
Gorge/ Gully
Hillcrest/ Hillslope
Medium Drainage Line
Sandy/Stony Plain
Undulating Low hills

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 13/04/2022

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8.4 Potential environmental impacts

8.4.1 Direct impacts

Potential direct impacts of the Proposal on fauna and fauna habitat have been identified as:

- Loss and fragmentation of fauna habitat
- Loss or injury of fauna individuals as a result of clearing (or other construction and operational interactions).

The assessment of these impacts in relation to MNES species is discussed in Section 12.

8.4.1.1 Loss and fragmentation of fauna habitat

This section presents the approximate loss of habitat based on the Conceptual Footprint; however, there is some flexibility to alter the final location of Proposal elements within the Development Envelope.

Clearing for the Proposal will result in the loss of up to 1,913 ha of native vegetation in predominantly Good to Excellent condition from eight mapped fauna habitat types (Table 8-10).

Based on the Conceptual Footprint, the habitat type that will be subject to the largest area of clearing (900 ha, representing 47% of total proposed clearing) will occur within the moderate value habitat type, Rocky Foothills. Based on the Conceptual Footprint, 694.7 ha of high value habitat (comprising Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope, Drainage Line and Spinifex Sandplain) will be removed by the Proposal.

Table 8-10: Indicative clearing of fauna habitats based on Conceptual Footprint

Habitat type (Biologic 2021a)	Habitat value	Total extent mapped by Biologic 2021a* (ha)	Extent in Development Envelope (ha)	Approximate extent within Conceptual Footprint (ha)	Approximate % loss from Development Envelope
Gorge/Gully	High	152.2	141.5	93.6	66.1
Breakaway/Cliff	High	27.8	26.3	17.0	64.7
Drainage Line	High	603.7	182.2	55.0	30.2
Hillcrest/Hillslope	High	814.0	707.9	504.6	71.3
Spinifex Sandplain	High	69.5	67.0	24.5	36.6
Rocky Foothills	Moderate	2,524.5	2,198.4	900	40.9
Spinifex Stony Plain	Low	1,452.5	1059.4	315.2	58.1
Calcrete Plain	Low	192.8	82.3	3.1	3.8

*Total extent mapped within the Development Envelope, within the SFEZ and outside of the Development Envelope

Clearing for the Proposal has the potential to result in habitat fragmentation, which may lead to altered movement patterns, genetic isolation, increased competition for resources in remaining connected habitats and reduced species richness.

8.4.1.1.1 Loss of habitat features

In addition to the broad habitat types, the Proposal will also impact caves and surface water pools. Caves provide important roosting habitat for MNES species including Ghost Bat and Pilbara Leaf-nosed Bat, therefore the potential impact on caves is discussed in Section 12.

A total of 15 surface water pools have been recorded within the Development Envelope, and an additional five are within the SFEZ. Fourteen surface water pools are located within the Conceptual Footprint, and one pool is located five metres from the Conceptual Footprint (WMPC-28). The Proponent expects to be able to avoid impacts to three pools (WMPC-03, WMPC-22 and WMPC-29), noting that impacts (i.e. a reduction) to the catchments may occur, resulting in a modification of inflows and potential changes to the persistence of water in these pools. Nevertheless, this assessment has conservatively assumed all 15 pools within the Development Envelope will be impacted as a result of the Proposal.

8.4.1.2 Loss or injury of fauna individuals as a result of clearing (or other construction and operational interactions)

Clearing of native vegetation will unavoidably result in the direct loss or injury of some vertebrate and SRE invertebrate fauna individuals. Injury or mortality of fauna can also result from collisions with vehicles and machinery during vegetation clearing, construction and operation of the Proposal, especially with species that are attracted to roads for basking or foraging activities and at night when nocturnal fauna actively forage. Whilst many native fauna species are highly mobile and capable of moving longer distances, some species have poorer dispersal abilities and are therefore more at risk.

8.4.2 Indirect impacts

Potential indirect impacts of the Proposal on fauna and fauna habitat have been identified as:

- Degradation or alteration of fauna habitat as a result of altered hydrological regimes and/or formation of pit lakes
- Disturbance to fauna from noise, vibration and light
- Habitat degradation associated with construction or mining activity, including transmission of weeds, dust or increased abundance of introduced fauna species.

Potential impacts on aquatic fauna are addressed in Section 6 as part of the Inland Waters factor and impacts to MNES species are addressed in Section 12.

8.4.2.1 Degradation or alteration of fauna habitats as a result of altered hydrological regimes and/or formation of pit lakes

Mine pits and infrastructure have the potential to reduce the catchment area of drainage lines, resulting in altered or degraded fauna habitats.

The creek catchment reductions from mining infrastructure are around 10% in McPhee Creek, Branch of McPhee Creek and Sandy Creek. Minimal catchment loss is expected for Spinaway Creek and there is no loss of catchment for Lionel Creek. These catchment losses would have a corresponding reduction in runoff and floor depth and volumes immediately downstream of the infrastructure. This is further discussed in Section 6.

Eleven permanent and two semi-permanent pools have been mapped in the areas surrounding the Development Envelope. The maximum catchment losses for these pools is 11% in the Branch of McPhee Creek permanent pool (VMPC-77) located closest to the Development Envelope.

The three pools that the Proponent expects to be able to avoid direct impacts to (WMPC-03, WMPC-22 and WMPC-29) may experience a catchment reduction.

Dewatering stages of the Proposal will result in the discharge of surplus water into creeks. The release of this water into the environment has the potential to alter the hydrological regimes within the creek catchments. The maximum wetting fronts for each of the creeks are:

- 15 km in McPhee Creek
- 7 km in Branch of McPhee Creek
- 12 km in Lionel Creek

Controlled discharge to these creeks will not be continuous and peak discharge will only occur early in mine life.

8.4.2.2 Disturbance to fauna individuals from noise, vibration, and light

Noise and vibration resulting from mining operations may cause avoidance behaviour in some species. The impacts of noise and vibration are greatest for bats (MNES) and are therefore addressed in Section 12.

Increased exposure to artificial light due to the construction and operation of the Proposal may have a detrimental impact on the resident bird, reptile and mammal species. Artificial light may interfere with activities governed by the length of the day, including reproduction, dormancy, foraging and migration. In particular, light emissions may attract invertebrates and alter the foraging activities of nocturnal species.

8.4.2.3 Habitat degradation associated with construction or mining activity, including transmission of weeds, dust or increased abundance of introduced fauna species

Construction activity and vehicle movements have the potential to introduce and/or spread weeds. Increased weed presence may degrade fauna habitats present and increase fire risk and intensity.

Clearing for construction, vehicle movements, and mine operation have the potential to generate dust, which may adversely affect fauna habitats. Native vegetation in the Pilbara tends to be tolerant of dust deposition (Matsuki et al. 2016); however, significant fauna habitats within the Development Envelope including bat caves and permanent or semi-permanent surface water pools, may be sensitive to high levels of dust. An air quality assessment found that some surface water pools within the Development Envelope may experience heightened levels of dust deposition (ETA 2021). The impact of dust on bat caves is addressed in Section 12.

Vegetation clearing can increase access of feral predators to fauna habitats, resulting in increased predation, causing injury or mortality of native fauna. Inappropriate waste management can also attract feral predators.

8.4.3 Cumulative impacts

Detailed fauna habitat mapping has been completed in the Development Envelope; however, detailed mapping at the same scale is unavailable for the Pilbara region. Land System mapping at a regional level by DPIRD provides an opportunity to assess cumulative impacts on broad landscape units as a surrogate for fauna habitat. The cumulative impacts on land systems have been considered within a 200 km radius of the Proposal, based on an assessment of proposed and undeveloped major mine projects. The projects within 200 km of the Proposal that have been assessed for cumulative impacts are outlined in Section 7.4.3. It is noted that the occurrence or relative disturbance to each land system are not presented in publicly available

impact assessment documentation for all projects. As such, estimates of the land system occurrence within each project was estimated by calculating the total area of each land system within the development envelopes of each project. Given this approach, the estimates are conservatively considering clearing occurring across the entire development envelope as opposed to the disturbance footprints of each project.

The cumulative losses of land systems are shown in Table 8-11.

Table 8-11: Cumulative impacts on land systems within a 200 km radius of the Proposal

Land system (unit)	Current extent in Chichester subregion (ha)	Approximate extent of loss from this Proposal based on Conceptual Footprint (ha; % of current extent)	Clearing from nearby projects* (ha)	Approximate cumulative clearing (ha; % of current extent)
Capricorn	482,779	1,408.8 (0.3%)	16,458	17,866.5 (3.7%)
Robe	25,182	75.6 (0.3%)	7,002	7,077.23 (28.1%)
Rocklea	2,123,354	345.3 (0.02%)	7,282	7,626.83 (0.36%)
Taylor	11,046	83.0 (0.8%)	-	83.0 (0.75%)

*Areas proposed to be cleared for each land system are based on the approved clearing limits or conservatively on the extent of the land system in the entirety of the development envelope. This is therefore a conservative estimate of the clearing of these land systems.

The greatest cumulative impact on land systems associated with the Proposal is the loss of approximately 28% of the Robe land system within the Chichester subregion. It should be noted that this loss is highly conservative, given that calculations were based on the approximate extent of the land system within the entire development envelope of each project, rather than the disturbance footprint.

Based on regional records (ALA 2022), each of the conservation significant fauna identified as occurring or likely to occur within the Development Envelope are known to extend beyond the Development Envelope and throughout the broader Pilbara region (Table 8-6).

8.5 Mitigation

During Proposal design, the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to avoid and minimise potential impacts of the Proposal to terrestrial fauna as far as practicable.

The Proponent has designed the Proposal to avoid direct impacts to high-value habitats by establishing a significant fauna exclusion zone (Section 2.5.3). The SFEZ has been excluded from mine planning for several years as it was recognised as a particularly high-value gorge system with five surface water pools, and a high number of MNES records. The exclusion zone will protect 115.1 ha of high-value fauna habitat (Table 8-12) (comprising Gorge/Gully, Hillcrest/Hillslopes and Breakaway/Cliff), one known cave (CMPC-25) and five surface water pools, including one permanent, one semi-permanent and three temporary/seasonal. The exclusion zone will exclude all mining activities and is located outside the Development Envelope.

Table 8-12: Fauna habitat located within the significant fauna exclusion zone

Fauna habitat	Habitat value	Area within SFEZ (ha)
Gorge/Gully	High	10.7
Breakaway/Cliff	High	0.2
Drainage Line	High	-
Hillcrest/Hillslopes	High	104.3
Rocky Foothills	Moderate	72.5
Spinifex Sandplain	High	-
Spinifex Stony Plains	Low	8.1
Calcrete Plain	Low	-
Total		**195.8**

Table 8-13 summarises the mitigation that will be applied to the Proposal.

Table 8-13: Application of mitigation hieracry for terrestrial fauna

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: loss and fragmentation of fauna habitat	• The Proponent has designed the Proposal to avoid direct impacts to areas of high-value habitat, including one cave (CMPC-25) and five surface water pools, through the establishment of the SFEZ. • The Proponent will avoid direct impact to seven bat roosts (further discussed in Section 12). • The Proponent will ensure no structural impact to four retained Ghost Bat roosts (CMPC-10, 13, 21 and 25). This is further discussed in Section 12, and management measures are outlined in the Terrestrial Fauna Management Plan (Appendix M). • The Proponent expects to be able to avoid direct impacts to three pools (WMPC-03, WMPC-22 and WMPC-29), noting that indirect impacts (i.e. a reduction) to the catchments may still occur resulting in a modification of inflows and potential changes the persistence of water in these pools.	• The Conceptual Footprint has been minimised as far as practicable to reduce clearing to no more than 1,913 ha of native vegetation (representing fauna habitat), including approximately 694.7 ha of high value fauna habitat within the Development Envelope. • Vegetation clearing areas will be clearly demarcated in the field, in accordance with the Proponent's Ground Disturbance Permit Procedure, and no clearing will occur outside the approved clearing areas.	• Progressive rehabilitation will be undertaken as areas become available and this will minimise the extent of cleared areas. • Rehabilitation will occur with vegetation comprised of native species of local provenance in accordance with the Mine Closure Plan (Appendix A). • Rehabilitation will incorporate fauna habitat niches through the incorporation of logs and rocks.	• Clearing of up to 1,913 of native vegetation comprising a range of different fauna habitats, including approximately 694.7 ha of high value fauna habitat.
Direct impact: loss or injury of fauna individuals as a result of clearing (or other construction and operational interactions)	• The Proposal has been designed to avoid impacts to high value fauna habitats as far as practicable through the establishment of the SFEZ. Retention of high value habitat will prevent loss or injury to fauna as a result of clearing.	• Vegetation clearing will commence from a disturbed edge to an undisturbed area, where practicable, to encourage mobile fauna to naturally relocate into adjacent areas. • Vehicle strike will be minimised by enforcing speed limits	• Not applicable.	• Loss or injury of fauna individuals as a result of the Proposal is expected to be managed through the implementation of a Terrestrial Fauna Management Plan (Appendix M).

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact

		within the Development Envelope.
		• Access to the SFEZ will be restricted.
		• Barbed wire fencing will be avoided where possible. If barbed wire fencing can't be avoided, reflectors will be installed to deter bats. This is discussed further in Section 12.
		• Fauna entrapment within mine infrastructure or equipment will be minimised through implementation of the following measures:
		  • All bins storing putrescible waste will have secure lids
		  • Skip bins will have access/egress ramps
		  • Domestic waste facilities will be fences
		  • Operational water sources (tanks, ponds, dams) will be fenced and/or have fauna egress mats installed.
		• The value of blocking access to diurnal caves for Ghost Bat during breeding season will be investigated (discussed further in Section 12 and the Terrestrial Fauna Management Plan (Appendix M)).
		• Fencing will be installed around turkeys' nests.
		• Personnel and visitors will undergo site inductions and awareness training.		

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		• Signage will be installed along roads where appropriate. • Significant fauna interactions/sightings are to be recorded to identify and better manage hotspots.		
Indirect impact: degradation or alteration of fauna habitat as a result of altered hydrological regimes and/or formation of pit lakes	• Avoidance of impacts to fauna habitat from mine dewatering and surface water discharge is not possible for this Proposal. • Avoidance of impacts to fauna habitat from the interruption to surface water runoff is not possible.	• Total volume of dewatering cannot be minimised. However, the Proponent is investigating an early commencement of dewatering (subject to approvals) to minimise peak dewatering rates. • Discharge rates will be managed between creeks to minimise impacts to pools and long-term mounding in alluvial aquifers. • Discharge locations will be constructed with scour and erosion protection. • Only water that is surplus to operational requirements will be discharged. • Surface water management during mining and closure will be designed to reduce adverse impacts on the natural function and environmental value of watercourses, water quality and sheet flow downstream of the mine area. • A Water Management Plan (Appendix B) will be implemented.	• Waste dumps will be rehabilitated at closure to ensure they are stable and revegetated. • Temporary infrastructure will be removed and natural flow paths and catchments, re-established in these areas.	• Impacts to fauna habitat as a result of altered hydrological regimes and/or formation of pit lakes will be managed through the implementation of the Water Management Plan (Appendix B).

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Indirect impact: disturbance to fauna individuals from noise, vibration, and light	• Details of mitigation measures for blast vibrations are applicable to caves utilised by bat species and are therefore discussed for MNES in Section 12.	• Direct lighting will be implemented to working areas only.	• Not applicable.	• Disturbance to fauna individuals from noise, vibration and light will be managed through the implementation of the Terrestrial Fauna Management Plan (Appendix M).

Indirect impact: habitat degradation associated with construction or mining activity, including transmission of weeds, dust or increased abundance of introduced fauna species	• The Proponent commits to avoiding the introduction of new weed species and spread of existing weed species through the implementation of hygiene procedures and weed management measures. Standard measures include the inspection of mobile plant/equipment arriving and departing from the Proposal.
	• Complete avoidance impacts to fauna of dust is not possible.
		• The Proponent commits to undertaking weed control in areas around the clearing front and in retained native vegetation adjacent to cleared areas.
		• Measures to be implemented to reduce feral predators include ensuring all bins storing putrescible waste have secure lids to avoid attracting fauna; recording feral fauna sightings; and implementing a feral cat control program in response to sightings.
		• The Proponent commits to implementing standard dust management measures to minimise dust emissions and subsequent deposition on retained native vegetation in proximity to disturbance. This may include, but is not limited to:
		  • Implementation of speed limits on unsealed roads
		  • Utilisation of water carts to limit dust generation from exposed surfaces
			• Weeds will be managed during closure as part of the rehabilitation process.
			• Progressive rehabilitation will be undertaken as areas become available and this will minimise the extent of cleared areas.
				• Habitat degradation associated with construction or mining activity, including the transmission of weeds, dust or increased abundance of introduced predators, will managed through the implementation of the Terrestrial Fauna Management Plan (Appendix M).

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		• Blast plans to consider meteorological conditions.		

8.6 Assessment and significance of residual impact

8.6.1 Direct impacts

8.6.1.1 Loss and fragmentation of fauna habitat

8.6.1.1.1 Vertebrate fauna habitat

The Development Envelope has been modified to avoid direct impacts to high-value fauna habitat (comprising Gorge/Gully, Breakaway/Cliff and Hillcrest/Hillslopes habitat types) by establishing the SFEZ. The SFEZ has been excluded from the Development Envelope due to the presence of an extensive gorge system and high-value habitats, including five surface water pools, in addition to numerous records of MNES in that location (Section 12).

The Proposal includes some flexibility to alter the final location of the Proposal elements within the Development Envelope. Regardless of where the final footprint is implemented, the Proposal will involve clearing up to 1,913 ha of native vegetation (as an authorised extent limit). This is considered a significant residual impact due to their habitat value for MNES and environmental offsets will therefore be provided (Section 13).

Based on the Conceptual Footprint, approximately 694.7 ha of high value habitat (comprising Breakaway/Cliff, Drainage Line, Gorge/Gully, Hillcrest/Hillslopes and Spinifex Sandplain) will be cleared for the Proposal. Detailed fauna habitat mapping has been completed for approximately 1,176.4 ha outside of the Development Envelope and the extent of the high value habitat types mapped outside of the Development Envelope is shown in Table 8-14.

Table 8-14: Extent of high value fauna habitat types mapped within and outside of the Development Envelope

Fauna habitat type	Total extent mapped by Biologic (2021a) (ha)	Extent within the SFEZ (ha)	Approximate extent in Development Envelope (ha)	Approximate extent in Conceptual Footprint (ha)	Approximate extent to be cleared (%)	Mapped extent remaining outside of Development Envelope (ha)
Gorge/Gully	152.2	10.7	141.5	93.6	66.1	-
Breakaway/Cliff	27.8	0.2	26.3	17.0	64.7	1.3
Drainage Line	603.7	-	182.2	55.0	30.2	421.5
Hillcrest/Hillslope	814.0	104.3	707.9	504.6	71.3	1.8
Spinifex Sandplain	69.5	-	67.0	24.5	36.6	2.6
Total	**1,667.2**	**115.2**	**1,124.9**	**694.7**	**61.8**	**427.2**

As shown in Table 8-14, approximately 421.5 ha of the Drainage Line habitat type has been mapped beyond the Development Envelope, indicating that this habitat type is not restricted and will continue to persist throughout the broader Pilbara region.

Only a limited extent of the other high value habitat types (Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope and Spinifex Sandplain) have been mapped beyond the Development Envelope. Detailed fauna habitat mapping has been completed for the Development Envelope and approximately 1,176.4 ha beyond; however, it is not available for the broader Pilbara region. Therefore, broad-scale Land System mapping has been used to assess the regional impacts of the loss of fauna habitats from the Development Envelope.

The fauna habitat types that occur within the Development Envelope are associated with four land systems: Capricorn, Robe, Rocklea and Taylor. An assessment of land systems provides an indication of the diversity and distribution of fauna habitats present surrounding the Development Envelope. Within a 20 km buffer of the Development Envelope (buffer taken from the centre of the Development Envelope, but calculations do not include the Development Envelope), there is 86,909.96 ha mapped as Rocklea and 25,158.09 ha mapped as Capricorn land systems. In the Development Envelope, the Rocklea land system was mapped predominantly Rocky Foothills and Spinifex Stony Plain habitat, also encompassing Calcrete Plain habitat. The Capricorn land system was predominately mapped as Hillcrest/Hillslope, Gorge/Gully, Rocky Foothills and Breakaway/Cliff habitat.

Approximately 4,911.41 ha of the Taylor land system is mapped within the 20 km buffer. Within the Development Envelope, the Taylor land system was mapped as corresponding with the Spinifex Sandplain and Spinifex Stony Plain habitat types. In addition, within 200 km of the Proposal, approximately 1,108,145 ha of these land systems are protected within conservation estate (namely Ex Meentheena Station Nature Reserve and Mungaroona Nature Reserve).

By comparing the quantity of mapped land systems (and mapped habitat) within the Development Envelope to the same land systems present (and predicted types of habitat) in the 20 km around the Development Envelope, it can be seen that these habitats are not restricted to the Development Envelope and will therefore remain available for use in the wider region.

Approximately 430.2 ha (38.2%) of high-value habitats will remain in the Development Envelope and each habitat type is considered to extend beyond the Development Envelope and throughout the broader Pilbara region (Biologic 2021a). While clearing is not expected to significantly affect the regional availability of these fauna habitats, this clearing is considered a significant residual impact and will be offset (Section 13).

Approximately 900 ha of moderate value fauna habitat (Rocky Foothills) will be cleared for the Proposal, representing 40.9% of the extent of this habitat type within the Development Envelope (Table 8-10). The loss of fauna habitat will result in reduced local availability of foraging and dispersal habitat for fauna. However, approximately 1,298.4 ha (59.1%) of this habitat will remain in the Development Envelope, 72.5 ha will remain within the SFEZ and 253.5 ha has been mapped outside of the Development Envelope. As such, this habitat type is considered to extend beyond the Development Envelope and throughout the Pilbara region (Biologic 2021a). Therefore, clearing is not expected to affect the regional availability of this fauna habitat.

Table 8-15 presents an assessment of clearing of fauna habitat types with the Development Envelope based on the Conceptual Footprint.

Table 8-15: Assessment of fauna habitat clearing based on the Conceptual Footprint

Fauna habitat	Assessment of impacts
Gorge/Gully (High value)	The Proposal will result in the removal of approximately 93.6 ha of Gorge/Gully habitat, representing 66.1% of the mapped habitat within the Development Envelope. Given the high value of this habitat type for conservation significant species and SRE (due to microhabitats), this is considered a locally significant residual impact to terrestrial fauna and environmental offsets will be provided (Section 13).
Breakaway/Cliff (High value)	The Proposal will result in the removal of approximately 17 ha of Breakaway/Cliff habitat, representing 64.7% of the mapped habitat within the Development Envelope. Given the high value of this habitat type for conservation significant species and SRE (due to microhabitats), this is considered a locally significant residual impact to terrestrial fauna and environmental offsets will be provided (Section 13).
Drainage Line (High value)	The Proposal will result in the removal of approximately 55 ha of Drainage Line habitat, representing 30.2% of the mapped extent within the Development Envelope. Given the high value of this habitat type for conservation significant species, this is considered a locally significant residual impact to terrestrial fauna and environmental offsets will be provided (Section 13).
Hillcrest/Hillslopes (High value)	The Proposal will result in the removal of approximately 504.6 ha of Hillcrest/Hillslopes habitat, representing 71.3% of the mapped habitat within the Development Envelope. Given the high value of this habitat, the clearing of approximately 504.6 ha is considered a locally significant residual impact to terrestrial fauna and environmental offsets will be provided (Section 13).
Spinifex Sandplain (High value)	The Proposal will result in the removal of approximately 24.5 ha of Spinifex Sandplain habitat, representing 36.6% of the mapped habitat within the Development Envelope. This habitat is considered low value for species other than the Greater Bilby, for which there are two small patches of suitable breeding habitat that are likely to support the species as a resident when in optimal condition. A large fire in 2015 destroyed much of this habitat within the Development Envelope, although this has been observed to have recovered well (Biologic 2021a). Future maturation of this vegetation will likely support the Greater Bilby within the Development Envelope. Given the potential of this habitat to be of high value for the Greater Bilby (a conservation significant species), the clearing of approximately 24.5 ha is considered a locally significant residual impact to terrestrial fauna and environmental offsets will be provided.

Fauna habitat	Assessment of impacts
Rocky Foothills (Moderate value)	The Proposal will result in the removal of approximately 900 ha of Rocky Foothills habitat, representing 40.9% of the mapped habitat within the Development Envelope. This habitat is of moderate value and is widespread and common throughout the Pilbara region. Given the retention of approximately 1,298.4 ha (59.1%) in the Development Envelope and retention of 72.5 ha within the SFEZ, this is not considered a significant impact.
Spinifex Stony Plains (Low value)	Approximately 315.2 ha (29.8% of the extent mapped within the Development Envelope) of Spinifex Stony Plains habitat will be cleared for the Proposal. This habitat is one of the most common and widespread habitat types throughout the region. Given this, and the low value of this habitat type for conservation significant species, clearing of this habitat type is not considered a significant impact.
Calcrete Plain (Low value)	The Proposal will remove approximately 3.1 ha of low value Calcrete Plain habitat, representing 3.8% of the mapped habitat within the Development Envelope. Given the low value of this habitat type for conservation significant species and its widespread nature throughout the region, this is not considered a significant impact to terrestrial fauna.

8.6.1.1.2 SRE invertebrate fauna habitat

Based on the Conceptual Footprint, approximately 670.2 ha (63.3%) of high and moderate/moderate to low value habitat for SRE invertebrate fauna (Gorge/Gully, Breakaway/Cliff, Hillcrest/Hillslope and Medium Drainage Line) will be cleared within the Development Envelope. This includes approximately 93.6 ha (66.2%) of high value SRE habitat (Gorge/Gully).

The Gorge/Gully habitat represents high value habitat to SRE invertebrate fauna as it provides adequate shade and shelter, complex rocky microhabitats, and patches of dense vegetation. Whilst a number of confirmed and potential SRE species were recorded within this habitat type (Antichiropus cunicularis n. sp. 'DIP026', Austrohorus' AES03', Indolpium' AES01', Xenolpium' PSE063', Buddelundia sp. 11 and Buddelundia sp. 18), none were restricted to this habitat type (Table 8-9 and Figure 8-10). The Gorge/Gully habitat is largely confined to the Main Range within the Development Envelope; however, 10.7 ha will be retained within the SFEZ. This habitat is not restricted to the Development Envelope and extends beyond the boundaries of the mapped extent. Given that none of the SRE species recorded are restricted to this habitat type, as well as the amount to be protected in the SFEZ, potential impacts from habitat clearing of Gorge/Gully habitat to SRE invertebrate fauna are not considered to be significant.

The Breakaway/Cliff habitat represents moderate value to SRE invertebrate fauna as it provides moderate/high levels of shade and shelter, complex rocky microhabitats and some degree of isolation, but is often more exposed than the Gorge/Gullies habitat type. Based on the Conceptual Footprint, the Proposal will result in the removal of approximately 17 ha of Breakaway/Cliff habitat, which represents 64.7% of the mapped extent within the Development Envelope. Eight confirmed and/or potential SREs were recorded within this habitat type. This habitat is considered to extend beyond the Development Envelope (see Section 8.6.1.1.1) and no species is restricted to the impact areas, therefore impacts from habitat loss are not considered significant.

Based on the Conceptual Footprint, the Proposal will result in the removal of approximately 55 ha of Drainage Line habitat, representing 30.2% of the mapped extent within the Development Envelope, and 504.6 ha of Hillcrest/Hillslopes habitat, representing 71.3% of the mapped habitat within the Development Envelope (Table 8-10). Both of these habitat types are low to moderate value for SRE invertebrate fauna, and widespread throughout the Development Envelope, extending into the wider region. None of the SRE invertebrate fauna recorded in these habitat types are singletons or restricted. In addition, 104.3 ha of Hillcrest/Hillslopes habitat will be protected within the SFEZ. Given the above, potential impacts to Medium Drainage Line and Hillcrest/Hillslopes habitats are therefore not considered to be significant for SRE invertebrate fauna.

8.6.1.2 Assessment of impacts against conservation significant fauna species

Discussion on impacts for MNES is provided in Section 12.

8.6.1.2.1 Long-tailed Dunnart (*Sminthopsis longicaudata*) (P4)

The Long-tailed Dunnart is a Priority 4 species. 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. The Long-tailed Dunnart was once considered rare but is now known to be relatively common and widespread in rocky habitats, throughout the northern Pilbara region, southwest to Morawa and east into the Gibson Desert (Burbidge et al. 2008 cited in Biologic 2020b). The ALA database contains 50 records of the species distributed through Western Australia, in addition to a separate population known to occur in the Northern Territory, near Alice Springs (ALA 2022; Biologic 2021a). Previous surveys in 2011 and 2012

have recorded this species in the Development Envelope in Breakaway/Cliff and Drainage Line habitat types, however the species was not recorded in the most recent survey (Figure 8-9; Biologic 2020b).

Based on the Conceptual Footprint, clearing for the Proposal will directly impact approximately 615.2 ha (70.3%) of Gorge/Gully, Breakaway Cliff, and Hillcrest/Hillslope fauna habitat types, considered suitable habitats for this species. However, approximately 260.5 ha (29.7%) of these fauna habitats will remain in the Development Envelope, in addition to 115.2 ha of these habitat types being retained within the SFEZ.

Given the widespread distribution and abundance of the species and its habitat, in addition to the retention of suitable habitat for the species within the Development Envelope and SFEZ, clearing for the Proposal is unlikely to significantly impact the regional population or the conservation status of the species.

8.6.1.2.2 Western Pebble-mound Mouse (*Pseudomys chapmani*) (P4)

The Western Pebble-mound Mouse is a Priority 4 species. Previous surveys (Outback Ecology 2012a, 2012b and 2014b) have recorded this species from secondary evidence (i.e. pebble mounds) in Hillcrest/Hillslope, Spinifex Stony Plain and Calcrete Plain habitats within the Development Envelope and Conceptual Footprint (Figure 8-9; Biologic 2020b).

The species is considered widespread outside of the Development Envelope and throughout the wider Pilbara region. Within the Hamersley subregion of the Pilbara, DPaW (formerly CALM) consider the species to be widespread and abundant (Kendrick 2001). The ALA database contains 220 location records of the species in Western Australia, with 65 of these records from the Chichester subregion and a total of 191 throughout the wider Pilbara region (ALA 2022). These records include locations of the Western Pebble-mound Mouse within conservation estate nearby the Proposal.

Based on the Conceptual Footprint, clearing for the Proposal will directly impact approximately 1,722.9 ha (42.6%) of Hillcrest/Hillslope, Rocky Foothills, Spinifex Stony Plain and Calcrete Plain fauna habitat hypes, which are considered suitable habitat for this species. However, approximately 2,324.8 ha (57.4%) of these fauna habitats will remain in the Development Envelope, in addition to 184.9 ha of these habitat types being retained within the SFEZ.

This species is widespread and common in the region, and the Proposal is unlikely to significantly impact the regional population or the conservation status of the species.

8.6.1.2.3 Gane's Blind Snake (*Anilios ganei*) (P1)

Gane's Blind Snake is found throughout the Pilbara bioregion, with 23 location records in the ALA database (ALA 2022). This includes records in conservation state, such as the Millstream Chichester National Park and Karijini National Park (noting that the location of these data points is an estimated location).

No significant impact is expected on the Gane's Blind Snake as they have not been recorded within the Development Envelope during any fauna surveys of the area. One individual was recorded approximately 0.7 km south of the Development Envelopment in a 2014 survey (Biologic 2021a). If the species was to be a resident within the Development Envelope, it would be most likely to shelter within Drainage Line and Gorge/Gully habitat types. Based on the Conceptual Footprint, approximately 148.6 ha of Gorge/Gully and Drainage Line habitat will be cleared, with approximately 45.9% of these habitat types to remain within the Development Envelope. In addition, 10.7 ha of Gorge/Gully habitat will remain within the SFEZ.

Given that this species has not been recorded within the Development Envelope, the retention of approximately 175.1 ha of high value habitat within the Development Envelope and the regional extent of these habitat types, the Proposal is unlikely to significantly impact the regional population or the conservation status of the species.

8.6.1.2.4 SRE invertebrate fauna

The majority of confirmed and potential SRE species recorded are unlikely to be restricted to the Development Envelope as they either occur in widespread habitats or were recorded from multiple sites and habitat types, indicating that they are not limited by habitat preference. In addition, the retention of 36.6% (387.8 ha; based on the Conceptual Footprint) of the high value habitat within the Development Envelope and retention of approximately 115.2 ha of Gorge/Gully, Breakaway/Cliff and Hillcrest/Hillslope within the SFEZ, will ensure that high and moderate value SRE habitat persists in the area.

Three confirmed SRE species have been recorded from the Development Envelope including *Antichiropus cunicularis* n. sp. 'DIP026', *Buddelundia* sp. 11 and *Buddelundia* sp. 18. The two Buddelundia species are both known from outside the Development Envelope, as well as from multiple sites and habitat types inside the Development Envelope (including the SFEZ). These species are therefore not restricted and are unlikely to be significantly impacted by the Proposal. The *Antichiropus* species is only known from inside the Development Envelope but was recorded from numerous sites across multiple habitat types (including the SFEZ). Any impact to this species is therefore not considered to be significant. A total of 13 potential SREs were recorded from the Development Envelope, which includes three species only known from outside the Conceptual Footprint: *Beierolpium*' sp. 8/4 lge', *Buthidae* sp. indet., and *Armadillidae* sp. indet (Table 8-9). Given their occurrence outside the areas of impact, these species are not considered further.

Four potential SRE species have been recorded from sites both within and outside the Conceptual Footprint and/or have been recorded from multiple sites in different habitat types and, as such are considered unlikely to be restricted including: *Indolpium* AES01, *Indolpium* AES03, *Xenolpium*' PSE063' and *Austrohorus* AES03 (Table 8-9).

Given that these four potential SREs occur across multiple habitat types, with some taxa also recorded in locations outside of the Conceptual Footprint, as well as the presence of suitable habitat remaining within the Development Envelope and SFEZ, the impact to these potential SRE species is not considered to be significant.

The remaining six potential SREs are only known from inside the Conceptual Footprint including: *Paradoxosomatidae* sp. indet, *Euryolpium* sp. indet., Genus' 7/4' sp. nov., *Indolpium*' AES02', *Idiopidae* sp. indet and *Olpiidae* gen. nov. (Table 8-9). These species are all singletons, only recorded from one site within one habitat type. The specimens collected were all juvenile and could not be identified to species level. It is possible that some of these taxa will represent species recorded elsewhere in the Development Envelope or will possibly have wider distributions than currently known. Genus' 7/4' sp. nov. and *Indolpium*' AES02' were recorded in widespread habitats with low perspectivity for SREs (Table 8-9). These species are therefore unlikely to be restricted and impacts to these potential SREs are not considered to be significant.

Paradoxosomatidae sp. indet., *Euryolpium* sp. indet. and *Idiopidae* sp. indet were all recorded within the Breakaway/Cliff habitat type, which occurs in a geographically restricted range. However, this habitat type is only moderately suitable for SREs as it is generally more exposed than other more suitable habitat types. Approximately 36% of this habitat type will be retained within the Development

Envelope, as well as within the SFEZ. Impacts to these taxa are therefore not considered to be significant, given that suitable habitat will be retained within the Development Envelope.

8.6.1.3 Loss of injury of fauna individuals as a result of clearing (or other construction and operational interactions)

The construction phase of the Proposal will occur predominantly during daylight hours with vegetation clearing commencing from a disturbed edge to an undisturbed area, where practicable, to encourage mobile fauna to naturally relocate into adjacent areas.

Vehicle speed limits will be implemented, reducing the potential for fauna strikes. In the event of a fauna strike, the impact will be limited to an individual and will not result in population-wide impacts. As a result, the potential impacts on fauna from interactions with vehicles and machinery are not expected to be significant. They will not affect the conservation status of any of the species present.

During operation, mining will be undertaken on a 24-hour basis, seven days per week. Light vehicle movements beyond the mine will occur mostly during the day. While there is potential for night-time vehicle and machinery movements to result in interaction, this is not expected to occur to the extent that it represents a significant impact to fauna species.

Whilst the loss of some native fauna individuals may be unavoidable, the number of individuals affected is expected to be low and not significant in terms of local populations. The use of vehicles and machinery associated with the Proposal are therefore considered unlikely cause significant impact or result in the significant decline of a population of any of the conservation significant vertebrate or SRE invertebrate fauna known to occur within the Development Envelope.

8.6.2 Indirect impacts

8.6.2.1 Degradation or alteration of fauna habitat as a result of altered hydrological regimes and/or formation of pit lakes

Fourteen of the fifteen pools in the Development Envelope are within the Conceptual Footprint, and the remaining pool (WMPC-28) is 4 m from the Conceptual Footprint, therefore, to be conservative, all 15 pools have been assessed as being potentially impacted by the Proposal. This includes:

- five permanent pools (WMPC-01, WMPC-03, WMPC-08, WMPC-09 and WMPC-22)
- two semi-permanent pools (WMPC-25 and WMPC-27)
- eight temporary/seasonal pools (WMPC-02, WMPC-26, WMPC-28, WMPC-29, WMPC-30, WMPC-31, WMPC-33 and WMPC-34).

It is noted that an additional five surface water pools, including one permanent pool, will be protected within the SFEZ. Twenty-three pools occur outside of the Development Envelope and SFEZ, in addition to the two reference pools. The maximum catchment losses for these pools is 11% in the Branch of McPhee Creek permanent pool (VMPC-77) located closest to the Development Envelope.

The Proposal is not expected to significantly impact the creekline catchments. McPhee Creek, Branch of McPhee Creek and Sandy Creek may experience catchment reductions of around 10% as a result of mining infrastructure. Spinaway Creek may experience minimal catchment loss, and no loss is expected for Lionel Creek. Some catchment flows are expected to be reinstated at closure. Given the rainfall patterns of the Pilbara, where most rainfall is episodic with generally short periods of runoff and creek flow, a small reduction in catchment and peak flows is unlikely to change the hydrological regime to the extent that it affects any environmental values.

Discharge of surplus water to surface water systems is a common practice at many operations in the Pilbara. Controlled discharge to the creeks nearby the Proposal will not be continuous and peak discharge will occur early in mine life. It is likely that the maximum wetting fronts on each creek would only be reached for a short time (one to three years), if at all. Discharges are not expected to have a significant impact to the environmental values along these creeks due to the short term nature of peak discharges and the adaptation of these creeks to highly variable flows. Following cessation of dewatering, the hydrological regimes will return to pre-mining conditions with long dry periods and slightly reduced peak flows due to catchment reduction.

Further discussion of hydrological regimes is described in Section 6.

8.6.2.2 Habitat degradation associated with construction or mining activity, including transmission of weeds, dust or increased abundance of introduced fauna species

As the Proponent is committed to implementing weed, dust and feral animal control management measures, it is not anticipated that there will be significant habitat degradation associated with these activities from construction or mining activity.

Even with potential elevated dust levels as a result of the Proposal, the fauna species within the Development Envelope are adapted to the dusty climate of the Pilbara, and dust emissions will not result in permanent changes to fauna habitat.

8.6.3 Cumulative impacts

The Proposal will result in the clearing of up to 1,913 ha of native vegetation, comprising eight broad habitat types, in addition to the potential clearing of approximately 159,000 ha from other projects within 200 km of the Proposal. The current (2018) extent of vegetation within the Pilbara region is 17,731,765 ha (GoWA 2019). Based on the predicted impacts, clearing for the Proposal will contribute a further 0.01% to vegetation clearing within the bioregion (Table 7-12).

Detailed fauna habitat mapping has been completed in the Development Envelope; however, detailed mapping at the same scale is not available for the IBRA Chichester subregion. Land System mapping at a regional level by DPIRD provides an opportunity to assess cumulative impacts on broad landscape units as a surrogate for fauna habitat.

The Proposal will also contribute to the cumulative clearing of four land systems that occur within the Chichester subregion: Capricorn, Robe, Rocklea and Taylor. The greatest cumulative impact is the Robe land system, with an estimated 28% loss of this land system from the subregion. However, these calculations are highly conservative as they considered the extent of the land system throughout the development envelopes of each surrounding project and did not assess the actual disturbance.

However, cumulative clearing in the Pilbara bioregion has been identified by the EPA as an area of concern (EPA 2014). Without the implementation of the strategies the EPA has outlined, it is believed that cumulative impacts of development in the Pilbara would have a significant effect on biodiversity and environmental values of the region. The PEOF aims to improve the conservation of biodiversity in the Pilbara. The clearing of up to 1,913 ha of native vegetation that comprises a range of different value habitat types for fauna species is considered to be a significant cumulative impact. Therefore, environmental offsets are proposed and outlined in Section 13.

8.7 Environmental outcome

The predicted impacts to terrestrial fauna from the Proposal after applying the mitigation hierarchy (avoid, minimise, rehabilitate) are:

- Clearing of up to 1,913 ha of native vegetation comprising a range of different value habitat types as identified in Table 8-16.

Table 8-16: Indicative clearing values for habitat types based on the Conceptual Footprint

Habitat type	Habitat value	Extent in Conceptual Footprint (ha)
Gorge/Gully	High	93.6
Breakaway/Cliff	High	17.0
Drainage Line	High	55.0
Hillcrest/Hillslope	High	504.6
Spinifex Sandplain	High	24.5
Rocky Foothills	Moderate	900.0
Spinifex Stony Plain	Low	315.2
Calcrete Plain	Low	3.1

- Removal of up to 13 identified caves, a number of which are utilised by conservation significant bat species and are therefore addressed in Section 12.
- Impacts to up to 15 surface water pools, including five permanent pools, two semi-permanent pools and eight temporary/seasonal pools. Noting that the Proponent expects to be able to avoid direct impacts to three pools (WMPC-03, WMPC-22 and WMPC-29), however indirect impacts (i.e. a reduction) to the catchments may occur resulting in a modification of inflows and potential changes to the persistence of water in these pools.
- Surplus water discharge is not expected to significantly impact to the fauna values along the creeks due to the short term nature of peak discharges and the adaptation of these creeks to highly variable flows.
- Dust, light, noise, vibration, weeds and feral cats are expected to be managed within the Development Envelope and are not predicted to result in significant impacts to terrestrial fauna
- Three confirmed SRE species and 13 potential SRE species occur within the Development Envelope; however, none will be significantly impacted.

Environmental offsets are proposed to counterbalance the significant residual impacts on vertebrate fauna from the removal of 694.7 ha of high value (Gorge/Gully, Breakaway/Cliff, Drainage Line, Hillcrest/Hillslopes and Spinifex Sandplain) fauna habitat based on the Conceptual Footprint are discussed in Section 13.

8.8 Conclusion

The residual impacts of the Proposal to terrestrial fauna and habitat are as low as reasonably practicable. There are significant residual impacts to high-value habitat at a local scale; however, the Proposal is not expected to adversely affect the conservation status of any species (including MNES and SREs). Environmental offsets are proposed for the clearing of approximately 694.7 ha of high value fauna habitat (Gorge/Gully, Breakaway/Cliff, Drainage Line, Hillcrest/Hillslopes and Spinifex Sandplain) based on the Conceptual Footprint and are discussed in Section 13. The Proponent therefore considers the Proposal can be managed to meet the EPA's objective to *protect terrestrial fauna so that biological diversity and ecological integrity are maintained*.

9 Subterranean Fauna

9.1 EPA environmental factor objective

The EPA's objective for subterranean fauna is *to protect subterranean fauna so that biological diversity and ecological integrity are maintained* (EPA 2021c).

9.2 Relevant policy and guidance

The relevant Policy and Guidance for Subterranean Fauna are described in Table 9-1.

Table 9-1: Relevant Policy and Guidance for Subterranean Fauna

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
Environmental Protection Authority	
Instructions on how to prepare an Environmental Review Document (EPA 2021d)	Considered during the development of this document
Statement of Environmental Principles, Factors and Objectives (EPA 2021c)	
Environmental Factor Guideline: Subterranean Fauna (EPA 2016c)	Considered in the design (methods and approach) of the subterranean fauna surveys or previous guidance (if survey undertaken before current guidelines)
Technical Guidance: Subterranean Fauna Survey (EPA 2016h)	
Technical Guidance: Sampling Methods for Subterranean Fauna (EPA 2016f)	
Other State or Commonwealth	
DMIRS Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines (DMIRS 2020c)	Considered in the development of this document and for the Mine Closure Plan (Appendix A)
Statutory Guidelines for Mine Closure Plans (DMIRS 2020b)	
WA Environmental Offsets Policy (GoWA 2011)	Considered in the impact assessment and offset strategy for subterranean fauna
WA Environmental Offsets Guidelines (GoWA 2014).	

9.3 Receiving environment

Subterranean fauna live underground and are typically grouped into two ecological categories:

- Troglofauna: air-breathing animals that inhabit caves, fissures and smaller voids above the water table
- Stygofauna: aquatic animals that inhabit groundwater in caves, aquifers, and water-saturated interstitial voids, i.e. occur within groundwater.

Obligate subterranean fauna (known as troglobites and stygobites) are species that live their entire lives underground and are completely dependent upon, and restricted to, subterranean habitats (EPA 2016h). These species are considered by the EPA to have an increased likelihood of short-range endemism and increased vulnerability to impacts from development (EPA 2016h).

In Western Australia, invertebrates such as crustaceans, insects, arachnids, myriapods, worms, and snails are the predominant subterranean taxa; however, several subterranean vertebrate taxa, such

as reptiles and fish, are also known (EPA 2016h). Some taxa can be characterised as both stygofauna and troglofauna as they are known to occur in groundwater as well as air-filled subterranean habitats (e.g. enchytraeid worms), whereas some other species occur within subterranean habitats for only part of their lifecycles and are not considered true troglobites or stygobites (Biologic 2021b).

The Proposal is located within the Pilbara bioregion which is recognised as a global hotspot for subterranean fauna biodiversity and is the best studied region for subterranean fauna in WA (EPA 2016h); therefore, subterranean fauna investigations were a key part of the environmental investigations for this Proposal.

9.3.1 Studies and survey effort

A number of subterranean fauna studies have been conducted for the Proposal including desktop assessments, field surveys and habitat assessments (Table 9-2).

Collectively, the subterranean fauna surveys cover the four proposed pits: Avon, Murray, Ord and Nicholson (collectively referred to as the Main Range hereon in), the proposed Crescent Moon pit (referred to as Crescent Moon hereon in), as well as regional areas (Figure 9-1 and Figure 9-2). The four most recent surveys (Biologic 2021c, 2020d, Subterranean Ecology 2012 and Ecologia 2011) provide sufficient sampling to cover the whole Development Envelope, with sampling effort that exceeds the EPA's minimum expectations in each area (i.e. 60 troglofauna samples and 40 stygofauna samples from areas considered likely to have significant values (EPA 2016h).

A total of 256 troglofauna samples and 78 stygofauna samples have been collected from the direct impact areas (i.e. proposed pits within the Main Range and Crescent Moon), 154 troglofauna samples and 76 stygofauna samples collected from indirect impact areas (i.e. waste dumps and stockpile locations), and 129 troglofauna samples and 26 stygofauna samples collected from reference sites (i.e. areas outside the direct or indirect impact areas) (Table 9-3).

Sampling methods used include a combination of troglofauna leaf-litter traps, troglofauna net scrapes (except Ecologia 2011) and stygofauna net hauls (Subterranean Ecology 2012 only; Table 9-2 and Table 9-3; Figure 9-1 and Figure 9-2). A breakdown of the survey and sampling methods in relation to the impact areas is provided in Table 9-3 and shown in Figure 9-1 and Figure 9-2.

Collectively, these surveys have been undertaken across two seasons: the wet and the dry season, which is recommended under EPA guidance (EPA 2016h). However, the number of sites within impact areas (direct and indirect) compared to reference areas is much higher which is not in accordance with EPA guidance which recommends an equal number of sample sites between areas (EPA 2016h). Despite this discrepancy, the high number of sample sites taken over multiple years is considered more than adequate to inform the impact assessment and is not considered to represent a constraint.

All the subterranean fauna studies have been conducted in accordance with the relevant guidance, where applicable. A summary of subterranean fauna surveys completed specifically for the Proposal is provided in Table 9-2.

Table 9-2: Subterranean fauna surveys conducted within the Development Envelope

Survey	Assessment type	Summary of survey effort and outcomes[1]
Mount Webber Iron Ore Project – Troglofauna Survey (Ecologia 2011)	Field survey	The McPhee Creek Proposal area was surveyed for troglofauna as part of the Mount Webber Project. The survey included sampling 70 drill holes at McPhee Creek as an 'outside of impact area' survey for the McPhee Creek Proposal and consisted of one sampling phase (August to September 2010; dry season) with a total sample size of 70 leaf litter traps (note that no net scraping was undertaken).
McPhee Creek Project Subterranean Fauna Survey (Subterranean Ecology 2012)	Field survey	Baseline wet and dry season survey in October-November 2011 and March-May 2012. Methods included troglofauna leaf-litter traps and net scraping, and stygofauna net hauling. Sampling effort included 51 troglofauna leaf-litter traps, 90 troglofauna net scrapes, and 93 stygofauna haul net samples. The survey identified 12 species of stygofauna and 20 species of troglofauna and determined groundwater quality to be within suitable limits. The survey was related to a previous Proposal design.
McPhee Creek Project: Subterranean Fauna Desktop Assessment (Biologic 2019c)	Desktop	Desktop assessment of subterranean species and habitats present within the study area, including integration of current regional context information, updated taxonomic and ecological information, updated habitat assessment and identification of potential implications for impact assessment.
McPhee Creek: Subterranean Fauna Assessment (Biologic 2021c; Appendix R)	Field survey	Consolidation of previous subterranean fauna survey work as well as an additional subterranean fauna survey undertaken at Avon Wet and Crescent Moon, between March and June (wet season) 2020. Sampling methods included troglofauna litter trapping and net scrapes. In addition, 3D habitat modelling was undertaken for the Main Range and Crescent Moon. The primary aim of this study was to determine the wider occurrence of troglofauna species and assemblages at Crescent Moon and identify important habitats beyond the potential impact areas.
McPhee Creek Project: Subterranean Fauna 3D Habitat Modelling Memo (Biologic 2021b; Appendix S)	Desktop	A desktop based assessment to create a three-dimensional (3D) model of the geological and hydrogeological habitats for subterranean fauna in key areas relevant to the Proposal and to validate the risk assessment for subterranean taxa potentially impacted by the Proposal.

1 further information of survey effort is provided in Appendix R

Table 9-3: Subterranean fauna sampling effort

Sampling methodology/study	Direct impact area (proposed pits)	Indirect impact areas (Conceptual Footprint excl. pits)	Reference sites (outside impact areas)	Total
Ecologia: Aug-Sep 2010				
Troglofauna litter trapping	59	9	2	70
Subterranean Ecology 2012*				
Troglofauna litter trapping	50	34	30	114
Troglofauna net scraping	64	45	49	158
Stygofauna net haul	78	76	26	180
Biologic 2020				
Troglofauna litter trapping	42	33	24	99
Troglofauna net scraping	41	33	24	98
Total				
Troglofauna litter trapping	151	76	56	283
Troglofauna net scraping	105	78	73	256
Stygofauna net haul	**78**	**76**	**26**	**180**
Troglofauna total	**256**	**154**	**129**	**539**
Stygofauna total	**78**	**76**	**26**	**180**
Total	**334**	**230**	**155**	**514**

* sampling effort shows total across two phases of survey

9.3.2 Conservation status and SRE classification

Subterranean fauna species and ecological communities may be considered significant through formal listing under the EPBC Act or the BC Act; however, there are many potential short-range endemic (SRE) subterranean species that are not formally listed, primarily due to incomplete regional sampling and low taxonomic certainty, which hinders formal recognition of species distribution ranges (Biologic 2021c)). In the absence of formal listings, subterranean fauna taxon can be assigned an SRE status category: Confirmed SRE, Potential SRE or widespread (i.e. not an SRE; Table 9-4) This categorisation indicates the potential for range restriction and thus informal conservation significance. These groupings are based on the Western Australian Museum's (WAM) categorisation for SRE invertebrates (Biologic 2021c).

Table 9-4: SRE categorisation used by WAM taxonomists

Taxonomic certainty		Taxonomic uncertainty
Distribution <10,000 km²	**Confirmed SRE** • a known distribution of <10,000 km² • taxonomy well known • group is well represented in collections and/or via comprehensive sampling.	**Potential SRE** • patchy sampling resulting in incomplete knowledge of geographic distribution • incomplete taxonomic knowledge

Taxonomic certainty		Taxonomic uncertainty
Distribution >10,000 km^2	**Widespread (not an SRE)** • a known distribution of >10,000 km^2 • taxonomy well known • group is well represented in collections and/or via comprehensive sampling.	• group not well represented in collections • category applies where there are significant knowledge gaps.

Source: Biologic 2021c]

9.3.3 Habitat suitability assessment

Three-dimensional (3D) habitat modelling to assess the prospective suitability of habitats within the Development Envelope was undertaken initially in 2019 and updated to include Crescent Moon in 2021 (Biologic 2019c; 2021c, 2021b). The initial 3D habitat assessment involved integrating cross-sectional diagrams from the previous habitat assessment report (Ecologia 2011), hydrogeological information, drill log information and diamond core photographs (provided by Atlas Iron), along with sampling from the previous baseline surveys (Ecologia 2011; Subterranean Ecology 2012) to provide an assessment of the likely extent and connectivity of potential subterranean habitats in the Main Range (Biologic 2021b). The 3D habitat modelling undertaken at that time was limited to the area within and immediately surrounding the locations of bores and drill holes (i.e., approximately 200 m around the outside of the drilled area) and was restricted to the four proposed pits within the Main Range (Biologic 2021b)).

Updated 3D habitat modelling undertaken in 2021 by Biologic involved creating a 3D stratigraphic model using Leapfrog® Geo software. This software creates a 3D geological model based on drill-hole logging data (representing geological codes, geospatial data, angle/ trace of drilling, and depth information) by implicitly connecting data points of the same geological units/ formations in 3D space (Biologic 2021c). Drill log data from holes throughout the Development Envelope were compiled into a database in Microsoft Excel® and codified (using consistent codes/ terminology across all drilling campaigns) to indicate stratigraphic units (strands) which were simplified into 'strand' groups. The strand groups were used to form 3D surfaces (meshes) of stratigraphic layers, including erosional layers, depositional layers, and faults/ unconformities. Other relevant information such as the inferred groundwater table, topographical surface, model boundary (extent of confidence), extent of proposed pits, extent of groundwater drawdown, and bores/ drill holes collar, angle and depth data was also incorporated to enable habitat assessment/ impact assessment relevant to subterranean fauna (Biologic 2021c). Scenes from the Leapfrog® Geo model were then exported to Leapfrog® Viewer 5.0 for presentation (Biologic 2021c; Appendix S).

The resulting 3D stratigraphic model was limited to the area within and immediately surrounding the locations of bores and drill holes, including an approximate 500 m buffer around the outside of the drilled area. This 500 m buffer represents the area of high confidence in the modelling of habitat suitability; however, it should be noted that suitable habitat does not cease to occur beyond the extent of modelling; it simply could not be modelled based on the information available at that time, and therefore any inferences of suitable habitat beyond the high confidence zone cannot be verified by 3D data at this time (Biologic 2021c).

Using the stratigraphic model as a basis, 3D modelling of suitable habitat was developed by categorising the geological and hydrogeological drilling data into high/ medium/ low suitability habitat for subterranean fauna (Biologic 2021c; Table 9-5). The vertical profile was divided by water

levels provided by Atlas Iron hydrogeologists, to separate the potential troglofauna habitat zone (above the water table) from the potential stygofauna habitat zone (below the water table).

Table 9-5: Habitat suitability rankings for subterranean fauna habitat

Habitat suitability rank	Typical geological characteristics	Subterranean fauna occurrence (within context of sampling)
Low	Impermeable, or very low permeability. Devoid of open fractures, secondary porosity, or cavities.	No evidence or very little evidence of fauna occurrence within this geology, in similar contexts.
Medium	May feature cavities, fractures, or porosity under some circumstances, or to a limited extent.	There is some evidence of subterranean fauna occurring in similar contexts, but not in all circumstances where this unit occurs. Assemblages not expected to be rich or abundant.
High	Often features caves/ cavities, fractures and/or secondary porosity or permeability, forming a well-developed network of interconnected voids.	Sampling throughout the region frequently detects rich and diverse subterranean fauna assemblages, almost always considered to be a key habitat for subterranean species.

Full details of modelling methods, results and cross-section diagrams are provided in Appendix S (Biologic 2021c).

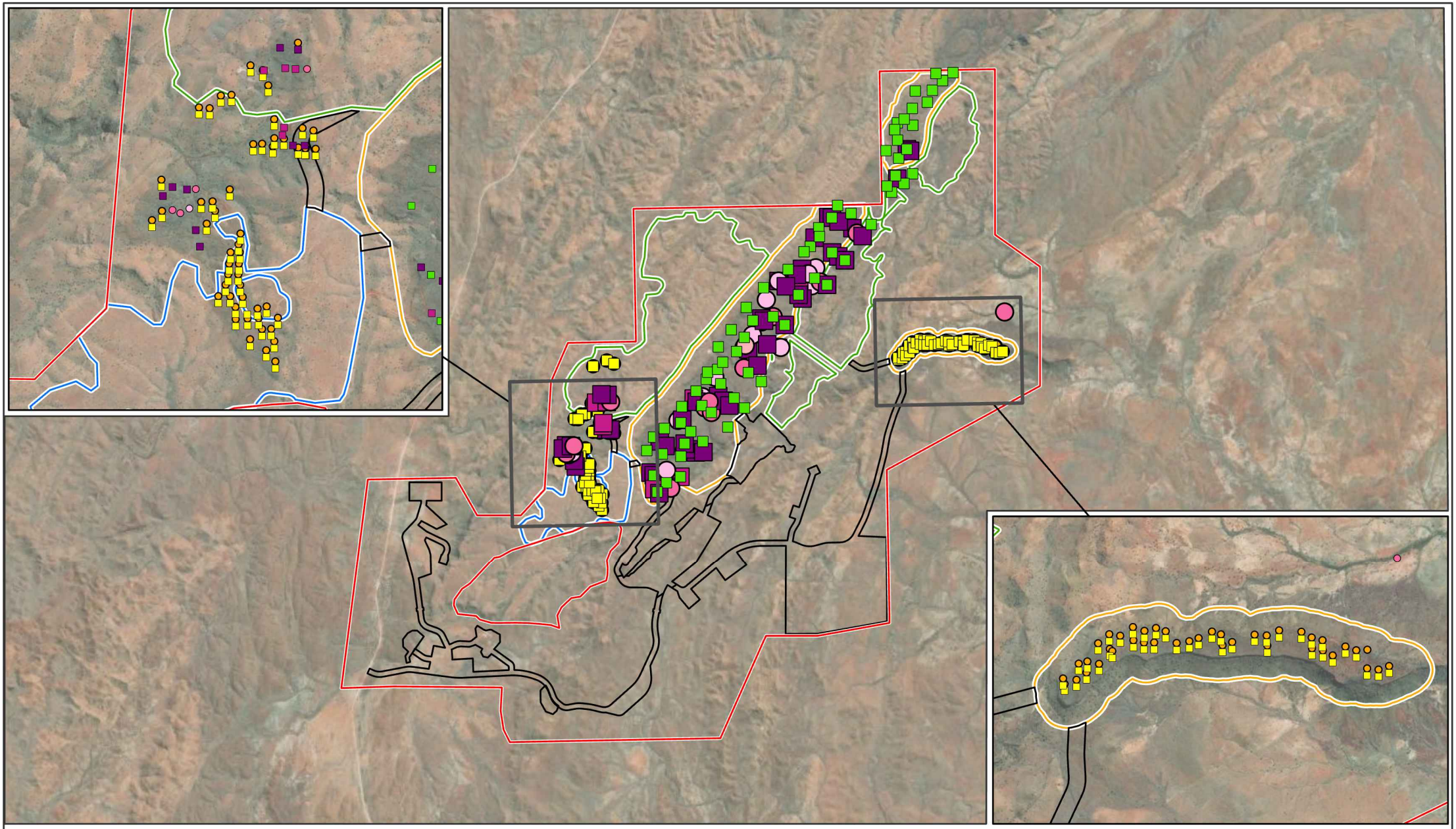

Figure 9-1: Troglofauna survey and sampling effort across the Development Envelope

Development Envelope
Reference Sites

Conceptual Footprint Elements
Direct Impact Sites (Pits)
Indirect Impact (Topsoil)
Indirect Impact (Waste Dump)

Subteranean Ecology 2012
Net Scrape
Net Scrape, Leaf Litter Trap
Net Scrape, Net Haul
Leaf Litter Trap, Net Scrape
Leaf Litter Trap, Net Haul, Net Scrape

Ecologia 2011
Leaf Litter Trap

Biologic 2020
Leaf Litter Trap
Net Scrape

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

N

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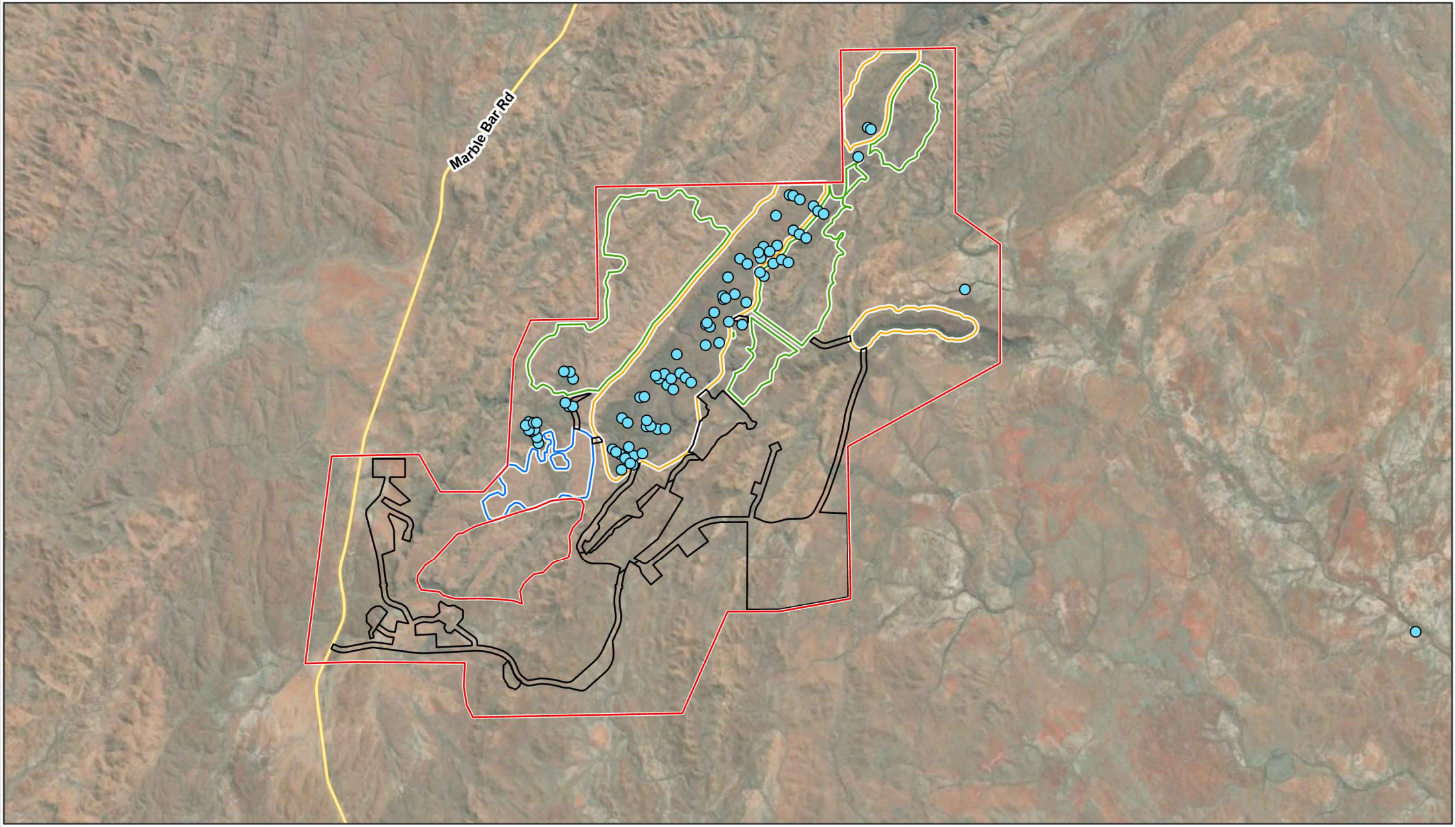

Figure 9-2: Stygofauna survey and sampling effort across the Development Envelope

Development Envelope
Reference Sites

Conceptual Footprint Elements

Direct Impact Sites (Pits)
Indirect Impact (Topsoil)
Indirect Impact (Waste Dump)

Stygofauna sample sites (Subterranean Ecology 2012)

Stygofauna Net Haul

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

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9.4 Troglofauna

9.4.1 Troglofauna habitat

Suitable habitats for troglofauna include habitats above the water table (AWT) such as caves, cavities, fractures, and vugs created by supergene weathering processes, and pore spaces within unconsolidated detrital material.

The recent habitat modelling undertaken by Biologic (2021c) indicates that Upper Banded Iron Formation (BIF), Lower BIF, and potentially Chert, within the Development Envelope represent medium/medium to high suitability habitat for troglofauna (Biologic 2021c). Highly suitable troglofauna habitat occurs within the Upper BIF, due to its occurrence close to the surface where it is highly prone to weathering and fracturing, and also within the Lower BIF, where supported by deeper fracturing. In addition, Chert appears to be fractured and weathered (i.e. not impermeable) and would therefore be expected to have medium suitability for subterranean fauna Biologic (2021c). Pockets of 'primary' and 'hydrated' mineralization occur throughout the Upper BIF and in some cases the Lower BIF, where secondary weathering has formed pores, vugs, cavities, and caverns. Such formations are known regionally to provide highly suitable habitats for subterranean fauna ((Biologic 2021c).

Medium and high suitability troglofauna habitat occurs throughout the Main Range, extending into an area of ridgeline to the south west of the Main Range which is not planned for development (Avon West; Figure 9-3; Biologic 2021c). The habitat model shows wider connectivity between layers of high suitability (primary and hydrated mineralization) and layers of medium to high suitability (Upper BIF and Lower BIF, and potentially Chert) throughout the Main Range and Avon West (Figure 9-3; Biologic 2021c).

A major fault line (the MP1 fault) runs through the Avon pit area, between Avon and Murray Pits from east to west (Figure 9-3). This fault does not completely disrupt the connectivity of suitable AWT habitat and may actually form a conduit for species dispersal due to associated fracturing of the habitable strata (Biologic 2021c). In addition, the West Fault runs between the Main Range and Avon West in a northwest to southeast direction. This fault coincides with a change in water level of approx. 37 m but does not appear to disrupt the connectivity of AWT habitat strata (Biologic 2021c). Geological disconformities occurring around the MP1 fault running between the Avon and Murray Pits and Avon West are apparent; however, interconnected BIF layers and mineralised pods also occur throughout the area, providing potential pathways for troglofauna to disperse. The occurrence of many shared species of troglofauna between the Main Range and Avon West indicates that the West fault and MP1 fault are unlikely to form barriers for troglofauna species dispersal

At Crescent Moon, the pisolith is a ferruginous duricrust deposit that includes massive, pisolitic, and nodular lateritic ironstone with interconnected networks of pore spaces, vugs, cavities, and caverns in pisolith deposits (Biologic 2021c). This habitat provides high suitability habitat for troglofauna (Figure 9-3; Biologic 2021c). The suitable habitat at Crescent Moon (pisolitic Channel Iron Deposit [CID]) is geologically distinct, and physically separated from other suitable habitats in the Main Range by topographical influences (mesa landforms) and the Eastbound Fault which runs along the eastern side of the Main Range, in a northeast to southwest direction. This fault coincides with a major change in geology which appears to separate the suitable habitat strata occurring in the Main Range from the suitable habitat strata occurring in the Crescent Moon area (Biologic 2021c). The occurrence of unique troglofauna assemblages at Crescent Moon, indicate that the eastbound fault may act as a barrier to dispersal between Crescent Moon and the Main Range to the west (Biologic 2021c).

The subterranean habitats identified by the 3D habitat modelling broadly align with the occurrence of the surface geology units shown in Figure 9-4, where the Ferruginous duricrust (Czrf) and (Paddy Market Formation (AGpcic) are inferred to provide suitable troglofauna habitat. The Czrf geology at Crescent Moon extends throughout the deposit along the top of the mesa landform but is discontinuous in the wider area beyond the deposit/ mesa (Figure 9-4). Subterranean fauna habitats extend throughout the Main Range, within the AGpcic Paddy Market Frm. BIF with ferruginous chert and into Avon West. Other geologies such as sandstone or banded chert, may provide potentially suitable troglofauna habitat under certain conditions, where fracturing and weathering processes have created sufficient cavities and pore spaces. Although outside of the 3D modelling boundaries, these geological units surround the primary habitats of the Main Range (Ferruginous duricrust and Paddy Market Formation) and may provide some connectivity between suitable habitat areas along the Main Range and Avon West. The inferred connectivity shown in the 3D modelling broadly aligns with the findings from sampling, which have shown a number of troglofauna species ranging throughout the Main Range (particularly Avon and Murray Pits) and Avon West, thereby demonstrating connectivity between these areas (Biologic 2021c).

Troglofauna trapping records indicated that troglofauna were sampled anywhere from 30 m to 50 m below surface in the Main Range. 3D habitat modelling has indicated that suitable habitat for troglofauna within the Main Range is likely to occur from near surface to the water table approximately 55m bgl along the Main Range (approximately 30 m bgl in Avon West). At Crescent Moon, the thickness of suitable habitat is likely to coincide with the thickness of pisolitic CID, which ranges from 10-24 m thickness at the top of the mesa landform, as the underlying shale is largely impermeable (Biologic*, pers. comms*).

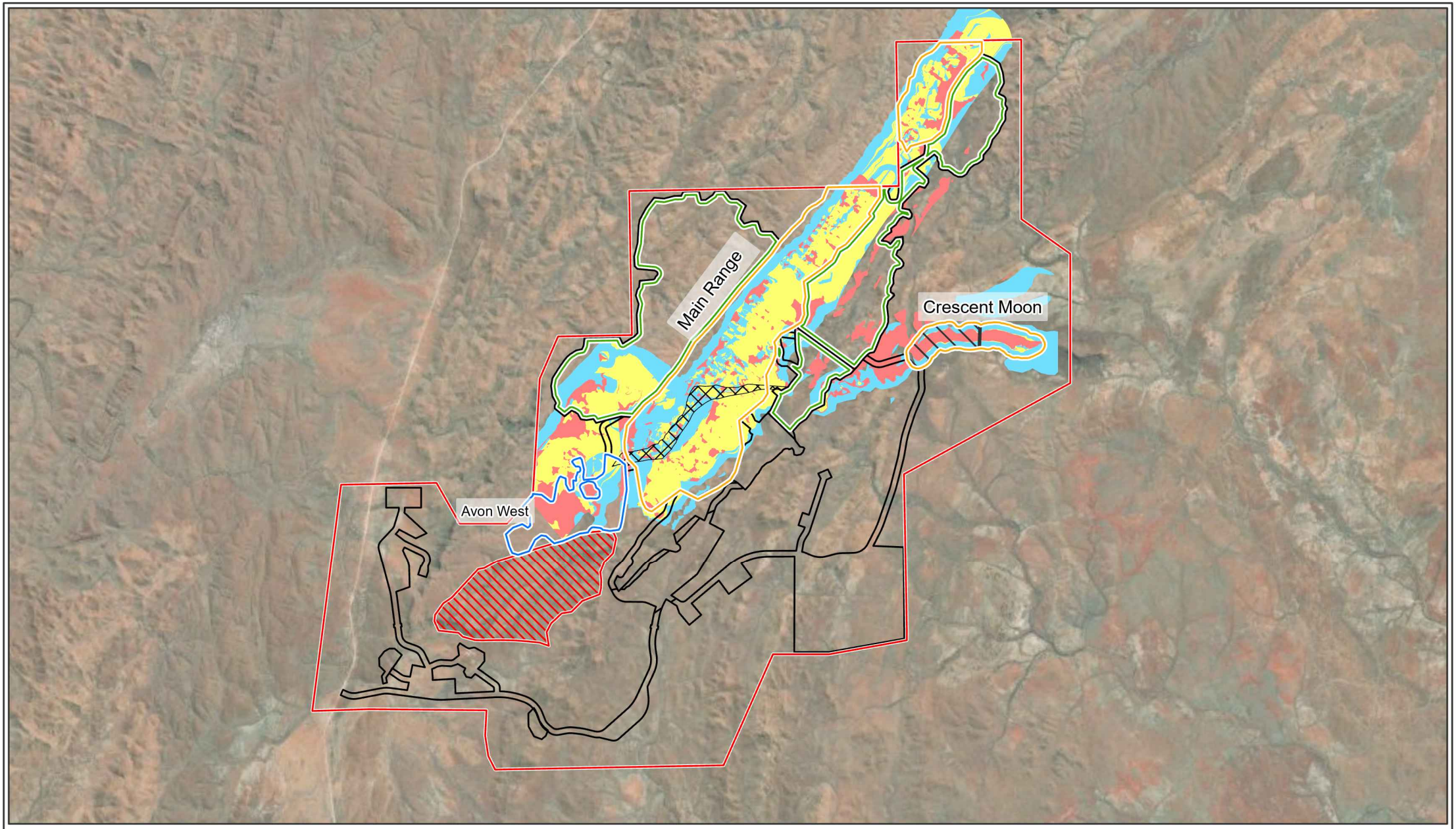

Figure 9-3: High and medium suitability Troglofauna habitat within the Development Envelope

- Conceptual Footprint
- Development Envelope
- Significant Fauna Exclusion Zone
- Major fault line
- Troglofauna Habitat Mining Exclusion Zone

Conceptual Footprint Elements

- Direct Impact Sites (Pits)
- Indirect Impact (Topsoil)
- Indirect Impact (Waste Dump)

Troglofauna habitat suitability

- High
- Med
- Low

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

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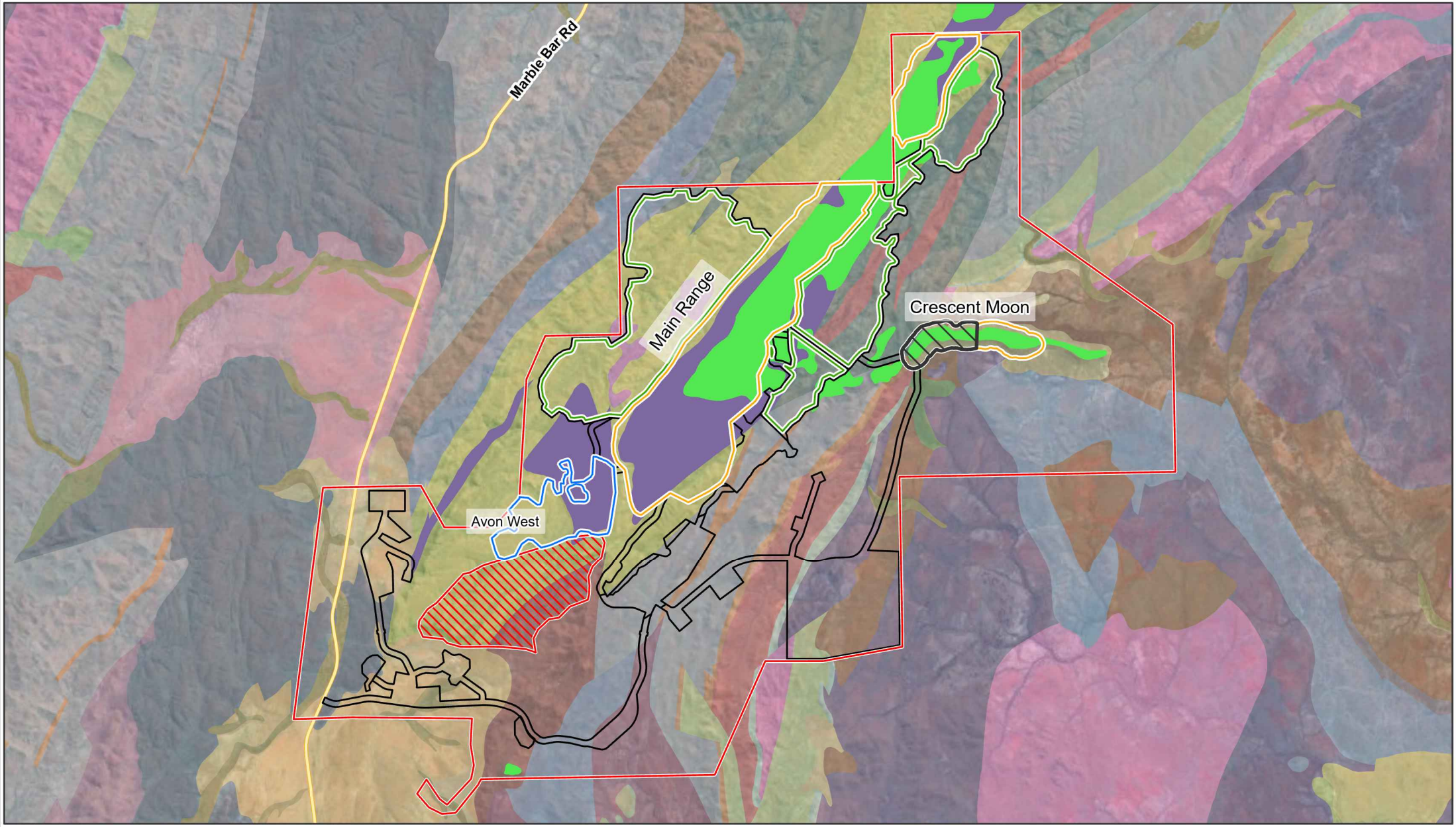

Figure 9-4: Surface geology and select taxa showing connectivity between areas

- Development Envelope
- Conceptual Footprint
- Significant Fauna Exclusion Zone
- Troglofauna Habitat Mining Exclusion Zone

Conceptual Footprint Elements

- Direct Impact Sites (Pits)
- Indirect Impact (Topsoil)
- Indirect Impact (Waste Dump)

Suitable surface geology for troglofauna

- AGpcic
- Czrf

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

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9.4.2 Troglofauna records

The combined troglofauna results (including current and previous surveys of the Development Envelope) recorded a total of 55 named taxa (including named species, morphospecies, and genetically derived taxonomic units; Table 9-6) and 18 indeterminate taxa (i.e. those that could not be identified to species level) from 14 higher order groups: Araneae, Palpigradi, Pseudoscorpiones, Diplura, Blattodea, Coleoptera, Hemiptera, Zygentoma, Geophilomorpha, Scolopendromorpha, Polyxenida, Pauropoda, Symphyla, and Isopoda (Biologic 2021c; note that the indeterminate taxa are not listed in Table 9-6).

Nine of the taxa are troglophiles or trogloxenes (i.e. species which do not live exclusively in subterranean habitats) and are likely to be widespread (Table 9-6):

- Araneae `sp. HLX AA001`
- Meenoplidae `sp. Biologic-HEMI013`
- Meenoplidae `sp. McP
- Polyxenida `sp. RRV`
- Pauropoda `sp. Biologic-PAUR004`
- Philosciidae `sp. McP
- Atelurinae `sp. Biologic-ZYGE028`
- Atelurinae `sp. Biologic-ZYGE029`
- Atelurinae `sp. McP`.

These species are not assessed further. The indeterminate taxa were either recorded outside of the direct impact areas or are likely to represent morphospecies recorded outside of direct impact areas and are not considered further (Biologic 2021c).

None of the troglofauna taxa, nor the communities recorded in the Development Envelope, are listed or recognised as conservation priorities under state or federal legislation (Biologic 2021c).

Details of each troglofauna species, SRE status, distribution and known area of occurrence are provided below in Table 9-6. Locations of troglofauna records are shown in Figure 9-5.

Table 9-6: Troglofauna taxa recorded within the Development Envelope

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Araneae						
Araneae `sp. Biologic-ARAN028`			2	0.14	Potential troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites outside of pit at Avon West.
Araneae `sp. HLX AA001`			1	>100	Likely terrestrial, Widespread	Molecular ID matched this species to specimens from near Pannawonica.
Gnaphosidae `sp. Biologic-ARAN029`		1		0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Linyphiidae `sp. Biologic-ARAN026`		3		0.6	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from three sites within pit at Crescent Moon.
Linyphiidae `sp. Biologic-ARAN027`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Oonopidae `sp. Biologic-ARAN024`			5	0.6	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from five sites outside of pit at Avon West.
Oonopidae `sp. Biologic-ARAN025`		1		0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Oonopidae `sp. McP`			2	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Palpigradi						
Palpigradi `sp. Biologic-PALP034`		1		0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Palpigradi `sp. Biologic-PALP035`		1		0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Palpigradi `sp. McP`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Pseudoscorpiones						
Chthoniidae `sp. Biologic-PSEU039`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Chthoniidae `sp. Biologic-PSEU040`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Chthoniidae `sp. Biologic-PSEU043`		1		0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Diplura						
Anajapygidae `sp. McP1`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit on the Main Range.
Anajapygidae `sp. McP2`			4	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit on the Main Range.
Anajapygidae `sp. McP3`			4	1.39	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from four sites outside of pit at Avon West.
Projapygidae `sp. Biologic-DIPL033`			1	0	Troglobite, Potential SRE	Known from one site outside of pit at Avon West.
Blattodea						
Nocticola `sp. McP`	25	5	58	5.69	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from multiple sites within pit and multiple sites outside of impact.
Coleoptera						

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Anillini `sp. McP1`	1	4	2	4.84	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from three sites within pit at Crescent Moon, one site within pit on the Main Range, and two sites outside of pit on the Main Range.
Anillini `sp. McP2`	1			0	Troglobite, Potential SRE	Morphological ID. Distinct from Anillini `sp. McP1`. Known only from one site inside pit on the Main Range.
Cryptorhynchinae `sp. Biologic-COLE011`			2	1.32	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites outside of pit at Avon West.
Curculionidae `sp. McP`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Pselaphinae `sp. McP`	1			0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit on the Main Range.
Staphylinidae `sp. Biologic-COLE005`			1	0	Troglobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Hemiptera						
Meenoplidae `sp. Biologic-HEMI013`		1	1	5.2	Trogloxene, Unlikely SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon and one site outside of pit at Avon West.
Meenoplidae `sp. McP`	2	1	3	4.69	Trogloxene, Unlikely SRE	Molecular ID showed this species to be a unique lineage. Known from three sites within pits and three sites outside of pit at Avon West and on the Main Range.
Zygentoma						

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Atelurinae `sp. Biologic-ZYGE028`		3	3	5.04	Trogloxene, Potential SRE	Molecular ID showed this species to be a unique lineage, however these could not be compared with Atelurinae `sp. McP` as different genetic regions were analysed. Known from two sites within pit at Crescent Moon and three sites outside of pit at Avon West.
Atelurinae `sp. Biologic-ZYGE029`		1		0	Trogloxene, Potential SRE	Molecular ID showed this species to be a unique lineage, however these could not be compared with Atelurinae `sp. McP` as different genetic regions were analysed. Known from one site within pit at Crescent Moon.
Atelurinae `sp. McP`	2		4	4.65	Trogloxene, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites within pit on the Main Range and four sites outside of pit at Avon West and on the Main Range.
Trinemura `sp. Biologic-ZYGE030`		4	1	5.24	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage, however these could not be compared with *Trinemura* `sp. McP` as different genetic regions were analysed. Known from four sites within pit at Crescent Moon and one site outside of pit at Avon West.
Trinemura `sp. Biologic-ZYGE031`			4	2	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage, however these could not be compared with *Trinemura* `sp. McP` as different genetic regions were analysed. Known from four sites outside of pit at Avon West.
Trinemura `sp. Biologic-ZYGE032`		1		0	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage, however it could not be compared with *Trinemura* `sp. McP` as different genetic regions were analysed. Known from one site within pit at Crescent Moon.

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Trinemura `sp. Biologic-ZYGE033`			1	0	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage, however it could not be compared with *Trinemura* `sp. McP` as different genetic regions were analysed. Known from one site outside of pit at Avon West.
Trinemura `sp. McP`			12	1.46	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within the 150 m pit buffer and four sites outside of pit at Avon West.
Geophilomorpha						
Chilenophilidae `sp. McP`	1			0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit on the Main Range.
Chilenophilidae? `sp. Biologic-CHIL010`			1	0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Scolopendromorpha						
Cryptops `sp. Biologic-CHIL016`		1		0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Cryptops `sp. McP`			1	0	Potential troglofauna, Potential SRE	Morphological ID. Could not be compared to *Cryptops* `sp. Biologic-CHIL016`. Known from one site outside of pit.
Polyxenida						
Polyxenida `sp. RRV`	2		2	>100	Trogloxene, Widespread	Molecular ID matched this species to specimens from throughout the Pilbara. Likely to represent cosmopolitan species *Lophoturus madecassus*.
Pauropoda						
Pauropoda `sp. Biologic-PAUR004`		2		>100	Likely soil fauna, Widespread	Molecular ID matched this species to a specimen from near Tom Price.

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Pauropoda `sp. Biologic-PAUR023`		1		0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Pauropoda `sp. Biologic-PAUR024`		2		0.05	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites within pit at Crescent Moon.
Pauropoda `sp. Biologic-PAUR025`		3		0.35	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites within pit at Crescent Moon.
Pauropoda `sp. Biologic-PAUR026`			3	0.07	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites outside of pit at Avon West.
Pauropoda `sp. Biologic-PAUR041`		1		0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Pauropoda `sp. Biologic-PAUR042`			1	0	Potential troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of pit at Avon West.
Pauropoda `sp. McP`	1			0	Potential troglofauna, Potential SRE	Morphological ID. Unable to compare to any other specimens. Known from one site inside pit on the Main Range.
Symphyla						
Hanseniella `sp. Biologic-SYMP033`		5		1.25	Likely troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from five sites within pit at Crescent Moon.
Hanseniella `sp. Biologic-SYMP034`			2	0.34	Likely troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites outside of pit at Avon West.
Isopoda						

Taxon	In Pit - Main Range	In Pit - Crescent Moon	Outside Pit	Linear range (km)	Ecological and SRE status	Identification and distribution comments
Armadillidae `sp. Biologic-ISOP031`		1		0	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Philosciidae `sp. McP`	2		4	1.91	Trogloxene, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from two sites within pit on the Main Range and four sites outside of pit at Avon West.
Troglarmadillo `sp. Biologic-ISOP030`		1		0	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit at Crescent Moon.
Troglarmadillo `sp. McP1`			2	0	Troglofauna, Potential SRE	Morphological ID. Distinct from *Troglarmadillo* `sp. McP2`. Known from one site outside of pit in Avon West.
Troglarmadillo `sp. McP2`	1		1	2.44	Troglofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site within pit on the Main Range and one site outside of pit at Avon West.

Source: Biologic 2021c). Text highlighted red indicates troglofauna species only known from the direct impact areas within the Conceptual Footprint.

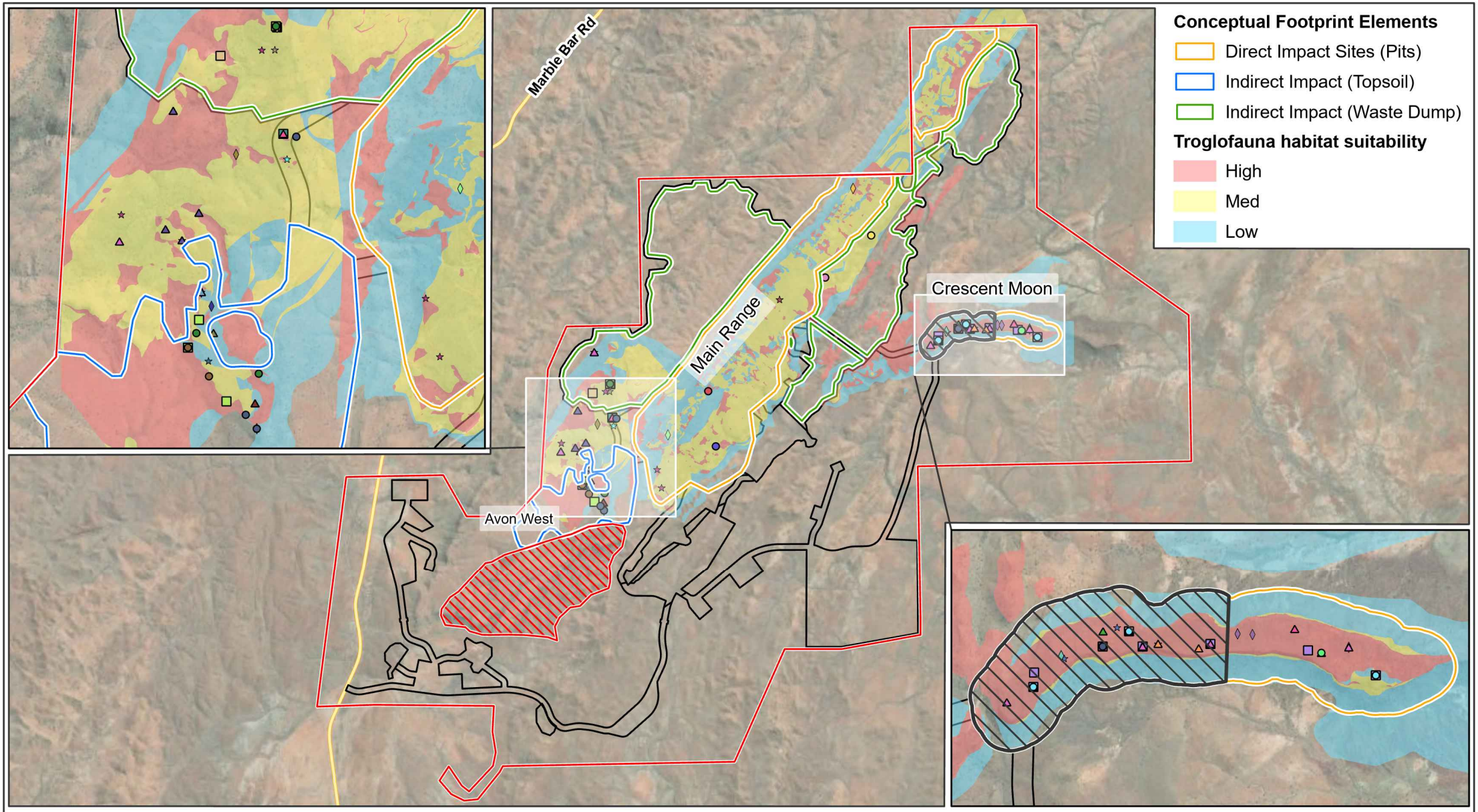

Figure 9-5: Troglofauna records within the Development Envelope

Conceptual Footprint
Development Envelope
Significant Fauna Exclusion Zone
Troglofauna Habitat Mining Exclusion Zone

Troglofauna Species

- Anajapygidae `sp. McP3`
- Anajapygidae sp. McP1
- Anajapygidae sp. McP2
- Anillini `sp. McP1`
- Anillini sp. McP2
- Araneae `sp. Biologic-ARAN028`
- Armadillidae `sp. Biologic-ISOP031`
- Atelurinae `sp. Biologic-ZYGE028`
- Atelurinae `sp. Biologic-ZYGE029`
- Chilenophilidae sp. McP
- Chilenophilidae? `sp. Biologic-CHIL010`
- Chthoniidae `sp. Biologic-PSEU039`
- Chthoniidae `sp. Biologic-PSEU040`
- Chthoniidae `sp. Biologic-PSEU043`
- Cryptops `sp. Biologic-CHIL016`
- Cryptops sp. McP
- Cryptorhynchinae `sp. Biologic-COLE011`
- Gnaphosidae `sp. Biologic-ARAN029`
- Hanseniella `sp. Biologic-SYMP033`
- Hanseniella `sp. Biologic-SYMP034`
- Linyphiidae `sp. Biologic-ARAN026`
- Linyphiidae `sp. Biologic-ARAN027`
- Meenoplidae `sp. Biologic-HEMI013`
- Meenoplidae `sp. McP`
- Nocticola `sp. McP`
- Oonopidae `sp. Biologic-ARAN024`
- Oonopidae `sp. Biologic-ARAN025`
- Oonopidae `sp. McP`
- Palpigradi `sp. Biologic-PALP034`
- Palpigradi `sp. Biologic-PALP035`
- Palpigradi sp. McP
- Pauropoda `sp. Biologic-PAUR023`
- Pauropoda `sp. Biologic-PAUR024`
- Pauropoda `sp. Biologic-PAUR025`
- Pauropoda `sp. Biologic-PAUR026`
- Pauropoda `sp. Biologic-PAUR041`
- Pauropoda `sp. Biologic-PAUR042`
- Pauropoda sp. McP
- Projapygidae `sp. Biologic-DIPL033`
- Pselaphinae sp. McP
- Staphylinidae `sp. Biologic-COLE005`
- Trinemura `sp. Biologic-ZYGE030`
- Trinemura `sp. Biologic-ZYGE031`
- Trinemura `sp. Biologic-ZYGE032`
- Trinemura `sp. Biologic-ZYGE033`
- Trinemura sp. McP
- Troglarmadillo sp. McP1
- Troglarmadillo sp. McP2
- Troglarmadillo`sp. Biologic-ISOP030`

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Kilometres

Datum/Projection:
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9.4.3 Potential environmental impacts to troglofauna

9.4.3.1 Direct impacts to troglofauna

Implementation of the Proposal will potentially result in the following direct impacts to troglofauna:

- Removal of troglofauna habitat
- Loss of troglofauna individuals.

9.4.3.1.1 Removal of troglofauna habitat

Pit excavation will result in the direct removal of suitable troglofauna habitat within the Main Range and at Crescent Moon. The Main Range area (including Avon West) and the Crescent Moon area provide distinct, discontinuous troglofauna habitats and as such, are assessed separately.

The potential loss and retention of zones of suitable habitat has been quantified using volumetric calculations (Biologic 2021c). By applying constraints to the 3D habitat model (refer to Section 9.3.3) at habitat boundaries such as dykes, faults, or water tables, as well as impact boundaries such as pit boundaries, the amount of suitable habitat left in-situ was tested against impact scenarios (i.e. pre-mining and post-mining; Biologic 2021c).

Based on this assessment of pit shells, approximately 30% of troglofauna habitat within the Main Range and 48% of troglofauna habitat within Crescent moon will be directly impacted by the Proposal (Biologic 2021c; Table 9-7).

The reduction in habitat across both areas as a result of the Proposal is considered to represent a medium level of impact, based on the following simple thresholds (Biologic 2021c):

- High = loss of pre-mining habitat volume >50% (retention of habitat <50%)
- Medium = loss of pre-mining habitat volume 50-30% (retention of habitat 50-70%)
- Low = loss of pre-mining habitat volume <30% (retention of habitat >70%).

Table 9-7: Summary of volumetric habitat loss vs habitat remaining 'in-situ' (high and medium habitats combined) under the Proposed mining

Habitat Volume	High & medium suitability combined ('000 m^3)	
	Loss	Remaining
Main Range area (inc. Avon West)	11,4774.5	26,4913.4
Crescent Moon area	1,842.0	2,031.4
Habitat (% of total pre-mining)	**High & medium suitability combined (%)**	
	Loss	**Remaining**
Main Range (inc. Avon West)	30.2	69.8
Crescent Moon area	47.6	52.4

9.4.3.1.2 Loss of troglofauna individuals

An assessment of the 46 troglofauna taxa considered relevant to the impact assessment has been undertaken as part of the impact assessment process (Biologic 2021c). The process of assessing the impact to taxa involved examining the distribution, ecological and habitat factors for each species and assigning a risk category of high, medium, or low risk of impact resulting from the Proposal, based on the criteria defined in Table 9-8 (Biologic 2021c).

Table 9-8: Risk categories for troglofauna

Risk category	Justification
High risk	The risk of impacts to the values is significant and/ or is not sufficiently managed/ mitigated under the current Proposal. Proposed impacts are likely to affect the long-term viability or persistence of the values.
Medium risk	The risk of impacts to the values is moderate and/ or is sufficiently managed/ mitigated under the current Proposal. Proposed avoidance, mitigation, or management strategies are likely to ensure the long-term viability or persistence of the values.
Low risk	Impacts are unlikely, or the risk of impact is insignificant under the current Proposal. The long-term viability or persistence of the values is not at risk.

Source: (Biologic 2021c)

Based on this assessment, a total of 20 troglofauna taxa were found to be restricted to the proposed pits at the Main Range and Crescent Moon (Table 9-9 and Figure 9-6). This includes four taxa only known from the Main Range ranked as medium risk, 15 species only known from Crescent Moon, ranked as high risk and one species ranked as medium risk within Crescent Moon (Table 9-9 and Figure 9-6; Biologic 2021c). The 26 remaining troglofauna taxa were ranked as low risk and are not discussed further.

An assessment of the potential direct impacts to the 20 species considered at risk is provided in Section 9.4.5.1.

Table 9-9: Troglofauna taxa potentially at risk from direct impacts of the Proposal

Taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Main Range				
Anillini `sp. McP2`	Troglofauna. Morphological ID could not align with any other specimen. May have similar distribution to Anillini `sp. McP1` found throughout the Main Range and at Crescent Moon.	Taxa collected from a single site (i.e. singleton) known only from Main Range.	Recorded from BIF or chert in the Paddy Market Formation which extends beyond pit to the south and west.	**Medium**
Pselaphinae `sp. McP`	Troglofauna. Molecular ID could not align with any other specimen. May have similar distribution to Anillini `sp. McP1` found throughout the Main Range and at Crescent Moon.	Singleton known only from Main Range.	Recorded from BIF or chert in the Paddy Market Formation which extends beyond pit to the south and west.	**Medium**
Chilenophilidae `sp. McP`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Main Range.	Recorded from BIF or shale in the Paddy Market Formation which extends beyond pit to the west, south-west, and below.	**Medium**
Pauropoda `sp. McP`	Potential troglofauna. Molecular ID failed due to contamination, so could not be aligned with other known morphospecies. May represent one of the other Pauropoda found outside impact areas.	Singleton known only from Main Range.	Recorded from BIF or shale in the Paddy Market Formation which extends beyond pit to the north-east, east, and below.	**Medium**
Crescent Moon				
Gnaphosidae `sp. Biologic-ARAN029`	Troglofauna. Molecular ID could not align with any other specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith.	**High**

Taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Oonopidae `sp. Biologic-ARAN025`	Troglofauna. Molecular ID could not align with any other specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith.	**High**
Linyphiidae `sp. Biologic-ARAN026`	Troglofauna. Molecular ID confirmed three specimens to be the same but could not align with any other specimens.	Known only from three sites within Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Chthoniidae `sp. Biologic-PSEU043'	Troglofauna. Molecular ID showed this species to be a unique lineage.	Known from one site within pit at Crescent Moon.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Palpigradi `sp. Biologic-PALP034`	Troglofauna. Molecular ID could not align with any other specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Palpigradi `sp. Biologic-PALP035`	Troglofauna. Molecular ID could not align with any other specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Atelurinae `sp. Biologic-ZYGE029`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of connectivity of this substrate with the Main Range is unknown. May extend below pit and is often known from soils habitats as well as subterranean.	**Medium**
Trinemura `sp. Biologic-ZYGE032`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Cryptops `sp. Biologic-CHIL016`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**

Taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Pauropoda `sp. Biologic-PAUR023`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Pauropoda `sp. Biologic-PAUR024`	Potential troglofauna. Molecular ID confirmed two specimens to be the same but could not align with any other specimens.	Known only from two sites within Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Pauropoda `sp. Biologic-PAUR025`	Potential troglofauna. Molecular ID confirmed two specimens to be the same but could not align with any other specimens.	Known only from two sites within Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Pauropoda `sp. Biologic-PAUR041`	Potential troglofauna. Molecular ID could not align with any specimen.	Singleton known only from Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Hanseniella `sp. Biologic-SYMP033`	Troglofauna. Molecular ID confirmed five specimens to be the same but could not align with any other specimens.	Known only from the Crescent Moon pit.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Armadillidae `sp. Biologic-ISOP031'	Troglofauna. Molecular ID showed this species to be a unique lineage.	Known from one site within pit at Crescent Moon.	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**
Troglarmadillo `sp. Biologic-ISOP030`	Troglofauna. Molecular ID showed this species to be a unique lineage.	Known from one site within pit at Crescent Moon	Recorded from CID/pisolith. Extent of habitat connectivity beyond the mesa landform is unknown. Unlikely to occur in shale beneath CID/pisolith	**High**

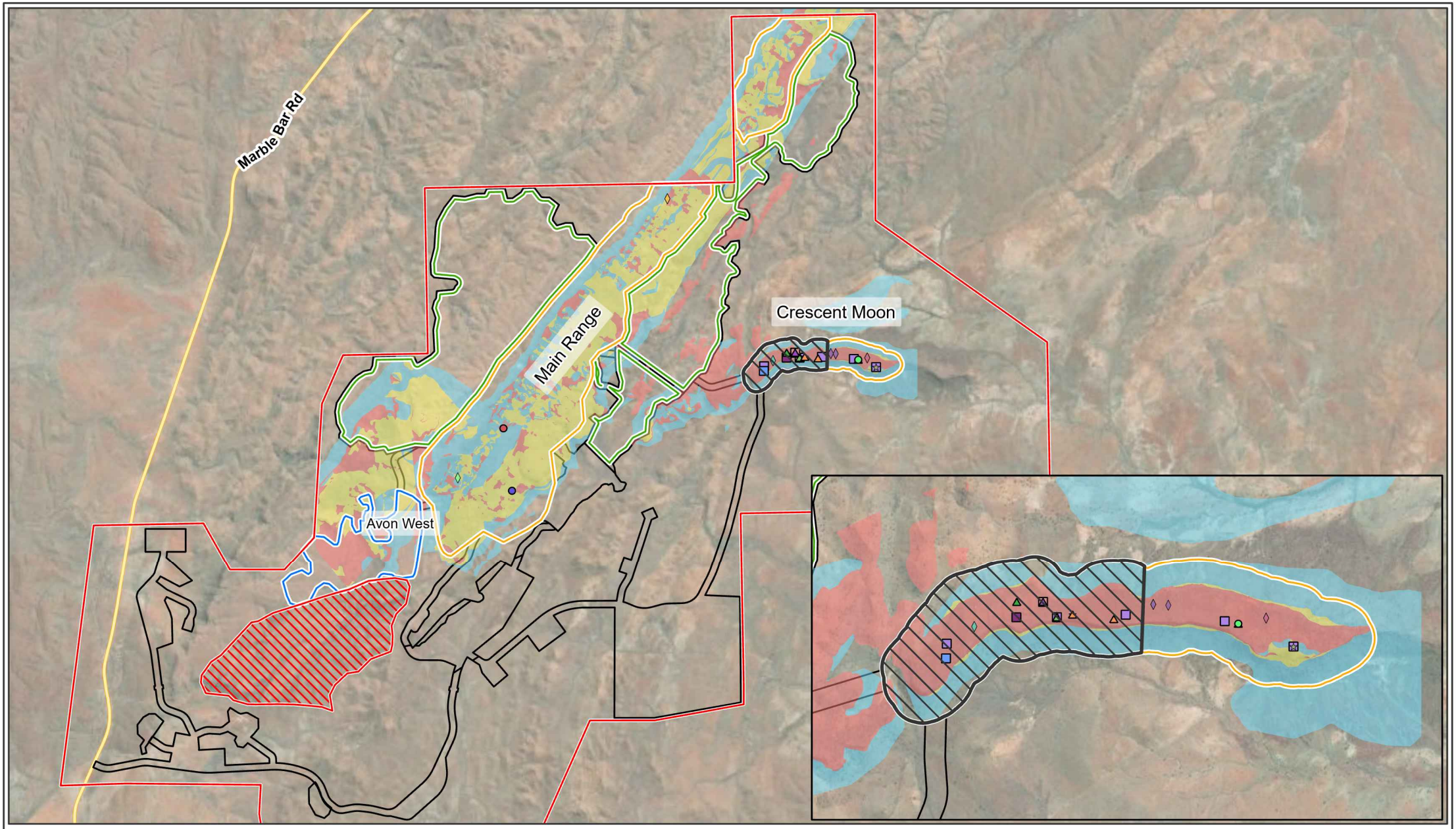

Figure 9-6: Locations of Troglofauna taxa potentially at risk from proposed impacts

Conceptual Footprint
Significant Fauna Exclusion Zone
Troglofauna Habitat Mining Exclusion Zone

Conceptual Footprint Elements
Direct Impact Sites (Pits)
Indirect Impact (Topsoil)
Indirect Impact (Waste Dump)

Troglofauna habitat suitability
High
Med
Low

Troglofauna Species

- Anillini sp. McP2
- Armadillidae `sp. Biologic-ISOP031`
- Atelurinae `sp. Biologic-ZYGE029`
- Chilenophilidae sp. McP
- Chthoniidae `sp. Biologic-PSEU043`
- Cryptops `sp. Biologic-CHIL016`
- Gnaphosidae `sp. Biologic-ARAN029`
- Hanseniella `sp. Biologic-SYMP033`
- Linyphiidae `sp. Biologic-ARAN026`
- Oonopidae `sp. Biologic-ARAN025`
- Palpigradi `sp. Biologic-PALP034`
- Palpigradi `sp. Biologic-PALP035`
- Pauropoda `sp. Biologic-PAUR023`
- Pauropoda `sp. Biologic-PAUR024`
- Pauropoda `sp. Biologic-PAUR025`
- Pauropoda `sp. Biologic-PAUR041`
- Pauropoda sp. McP
- Pselaphinae sp. McP
- Trinemura `sp. Biologic-ZYGE032`
- Troglarmadillo`sp. Biologic-ISOP030`

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9.4.3.2 Indirect impacts

Indirect impacts to troglofauna potentially include the degradation of subterranean fauna habitats from vegetation clearing, vibration, changes in surface hydrology and/or contamination.

Little is known about the origin of energy (i.e. organic carbon), key taxa or connectivity within the food web of subterranean systems. Organic carbon, moisture, and oxygen is expected to originate from the surface and be transferred into the subterranean environment by infiltration of water through soil voids (preferentially via plant root systems) and geological fissures. In particular cave systems, energy may be generated in via chemo-autotrophic processes, where bacteria use alternative metabolic pathways to provide energy inputs (EPA 2016h), although there is no evidence of this occurring in the Pilbara region to date.

As the subterranean ecosystem is expected to be dependent on surface inputs of energy and water, clearing of vegetation and placement of mineral waste material or topsoil stockpiles may lead to a reduction of these inputs and potentially a reduction of the quality of troglofauna habitat. Little evidence is available examining the indirect impacts of above-ground disturbances such as vegetation removal, and creation of infrastructure, waste dumps and stockpiles, although it is likely that any impacts would be limited to habitats directly beneath the footprint of disturbance.

Similarly, the potential exists for subterranean habitats and groundwater to become contaminated from the placement of waste dumps, placement of overburden or topsoil stockpiles, the disposal of waste fines, exposure of PAF material, storage of PAF in waste dumps, post-closure formation of pit lakes and/or handling of hazardous materials or wastes. These activities could potentially result in harmful substances infiltrating into the subterranean environment, thereby making previously suitable troglofauna habitat uninhabitable for subterranean fauna.

Blasting activities and vibration may also have the potential to alter subterranean fauna habitats; however, these risks are generally considered very localised to the immediate vicinity of the pit walls.

Troglofauna rely on relatively stable temperature and humidity conditions underground and are highly susceptible to the effects of desiccation from changes to water tables or surface inputs of moisture from rainfall (EPA 2016f). The combined effects of groundwater drawdown and alterations to surface hydrology may have some potential to reduce the humidity of subterranean habitats.

9.4.3.3 Cumulative impacts to troglofauna

Given that there are no mining projects within a 20 km radius of the Proposal, there will be no cumulative impact to SRE troglofauna as a result of implementation of the Proposal.

9.4.4 Mitigation

During Proposal design, the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to avoid and minimise potential impacts of the Proposal to troglofauna and associated environmental values as far as practicable.

Impacts to troglofauna have been mitigated through the exclusion of an area of ridgeline to the south west of the Main Range, known as Avon West. Avon West is connected to the Main Range but is not planned for mining. This area also consists of high and medium suitability habitat for troglofauna and

will continue to provide refugial habitat for troglofauna species impacted by development of the pits at the Main Range (Figure 9-3 and Figure 9-4; Biologic 2021c).

A proposed topsoil stockpile and waste dump will be located over a portion of Avon West (Figure 9-3). The stockpile and waste dump were positioned here so as to avoid the SFEZ and are located where the depth to the water table is over 40 m (minimum depth to water table is 40 m and maximum depth 120 m) and therefore less at risk from indirect impacts associated with contamination or sediment transport. Indirect impacts to troglofauna have been avoided within an approximately 2.2ha area within the perimeter of the larger topsoil stockpile area (Figure 9-3). This area consists of high suitability habitat for troglofauna which is connected to areas that extend outside the Conceptual Footprint. Other management measures will be implemented to minimise any potential indirect impacts to troglofauna associated with habitat degradation from placement of the topsoil stockpile or waste dump and include limiting topsoil stockpile heights to less than 2 m (Table 9-10).

Impacts to troglofauna taxa and assemblages will be further minimised through the continued availability of medium and high suitability troglofauna habitat below and surrounding the direct impact areas within the Main Range post-mining (Biologic 2021c). The habitats within the Main Range extend into Avon West and beyond the Development Envelope (Biologic 2021c).

Impacts to troglofauna at Crescent Moon will be mitigated through the inclusion of a Provisional Mining Exclusion Zone, which will be temporarily placed across the western half of Crescent Moon (Figure 9-7). This area will not be mined (however will have haul road installed to access the eastern portion), until such a time that the Proponent can demonstrate that troglofauna habitat recorded at Crescent Moon is connected and occurs in areas outside those proposed for mining. This will be targeted through the further habitat modelling and sampling work within the Troglofauna Investigation Areas (Figure 9-7; refer to Section 9.4.5.1).

Other impact minimisation strategies relevant to the entire Development Envelope include (but are not limited to):

- Hydrocarbon management measures to reduce the risk of contamination of troglofauna habitat
- Management strategies to reduce habitat degradation risks associated with PAF, pit lake formation, hydrocarbon storage and erosion are described in Section 6.

A summary of the proposed avoidance and mitigation measures are provided in Table 9-10.

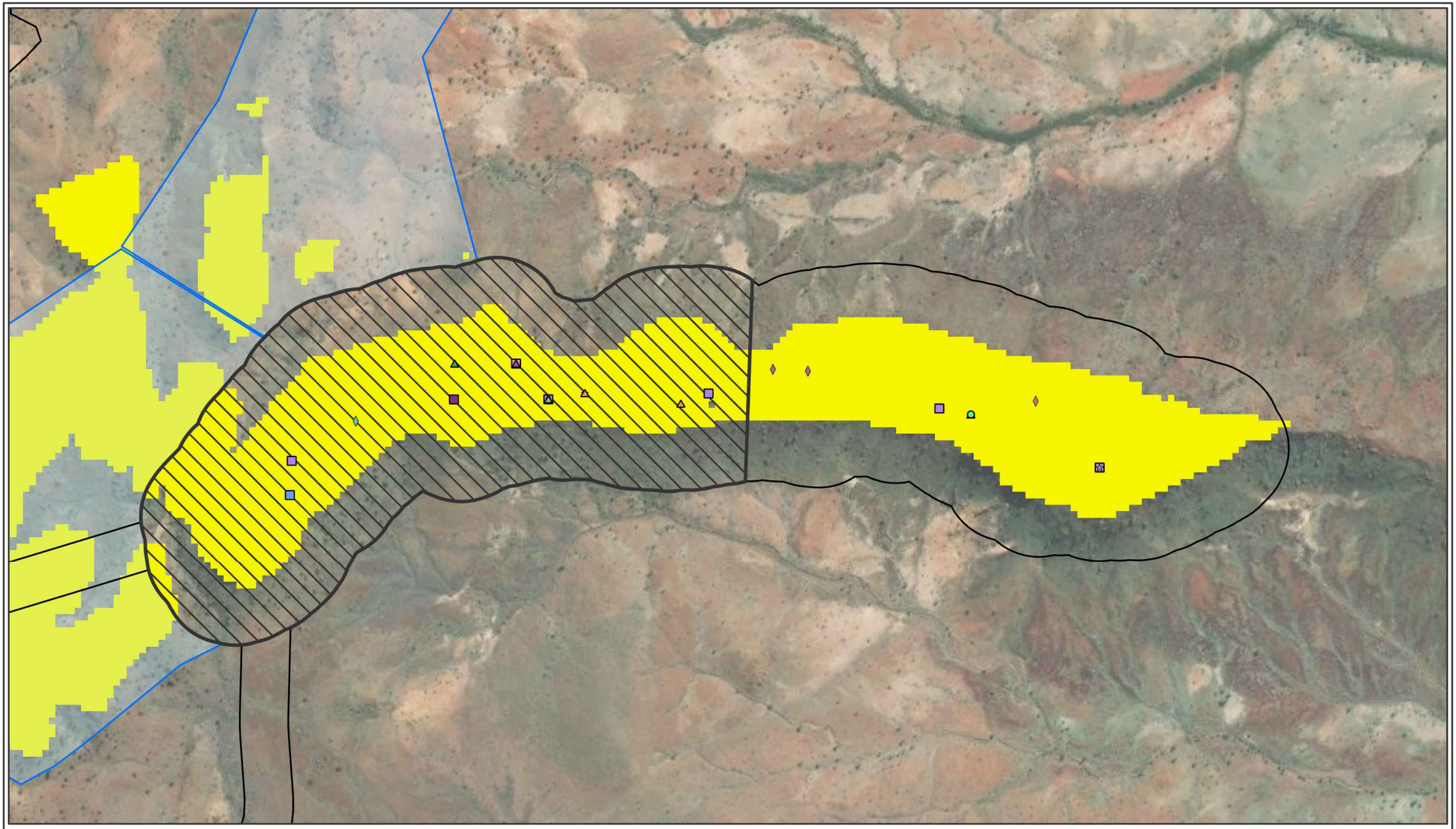

Figure 9-7: Crescent Moon Troglofauna Investigation areas and Provisional Mining Exclusion Zone

- Conceptual Footprint
- Troglofauna Habitat Mining Exclusion Zone
- Troglofauna Habitat Investigation Area
- Modelled Troglofauna Habitat (Potential and Confirmed)

Troglofauna Species

- Armadillidae `sp. Biologic-ISOP031`
- Atelurinae `sp. Biologic-ZYGE029`
- Chthoniidae `sp. Biologic-PSEU043`
- Cryptops `sp. Biologic-CHIL016`
- Gnaphosidae `sp. Biologic-ARAN029`
- Hanseniella `sp. Biologic-SYMP033`
- Linyphiidae `sp. Biologic-ARAN026`
- Oonopidae `sp. Biologic-ARAN025`
- Palpigradi `sp. Biologic-PALP034`
- Palpigradi `sp. Biologic-PALP035`
- Pauropoda `sp. Biologic-PAUR023`
- Pauropoda `sp. Biologic-PAUR024`
- Pauropoda `sp. Biologic-PAUR025`
- Pauropoda `sp. Biologic-PAUR041`
- Trinemura `sp. Biologic-ZYGE032`
- Troglarmadillo`sp. Biologic-ISOP030`

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Table 9-10: Application of mitigation hierarchy for troglofauna

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: removal of troglofauna habitat	• Troglofauna habitat has been avoided through the retention of Avon West, which is not planned for to be developed. • Fifteen troglofauna taxa are known only from the proposed Crescent Moon pit. With no mitigation strategy, risks to all 15 species would be considered high. Therefore, in order to address this unacceptable impact, the Proponent commits to mining only 50% of the surface extent within Crescent Moon, until such a time that it can be demonstrated that the troglofauna habitat of Crescent Moon occurs in areas outside those to be impacted either through additional habitat modelling and/or additional sampling.	• Impacts to troglofauna habitats will be minimised through retention of connected medium and high suitability habitat throughout Avon West.	• Areas that are no longer in use will be rehabilitated as soon as practicable. • Progressive rehabilitation will be undertaken which will assist in re-establishing nutrient flows into the subterranean environment.	• Removal of up to 30% of medium and high suitability troglofauna habitat within the Main Range • Retention of at least 70% medium and high suitability troglofauna habitat within the Main Range • Removal of up to 48% of medium and high suitability troglofauna habitat, if the Proponent can demonstrate that the troglofauna assemblage at Crescent Moon is not restricted. • If the Proponent cannot demonstrate that the troglofauna assemblage at Crescent Moon is not restricted, then only 24% of medium and high suitability troglofauna habitat will be removed within the eastern section of Crescent Moon.

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: loss of troglofauna individuals	• Avoidance of loss of some troglofauna individuals is not possible for this Proposal	• Impacts to troglofauna individuals will be minimised through: o retaining medium and high suitability troglofauna habitat throughout Avon West which is connected to habitat that extends beyond the Development Envelope.		• Direct impacts to the following four troglofauna taxa within the Main Range: o *Anillini* `sp. McP2` o Pselaphinae `sp. McP` o Chilenophilidae `sp. McP` o Pauropoda `sp. McP`. • All four taxa were recorded in habitat that extends beyond the areas of impact. • All four taxa are expected to have wider distributions than currently known. • At least 70% high and medium suitability habitat that is connected to areas outside the impact areas will be retained. • Direct impacts to six taxa at Crescent Moon: o Pauropoda 'sp. Biologic-PAUR024' o Pauropoda `sp. Biologic-PAUR025' o *Hanseniella* `sp. Biologic-SYMP033' o Armadillidae `sp. Biologic-ISOP031' o Linyphiidae `sp. Biologic-ARAN026`

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
				○ *Trinemura* `sp. Biologic-ZYGE032`. • The retention of suitable troglofauna habitat in pisolith/CID geologies beneath and alongside the Crescent Moon pit which is connected to undisturbed habitat remnant within the Provisional Mining Exclusion Zone in the western section of Crescent Moon.
Indirect impacts: degradation of troglofauna habitat from clearing, vibration, changes in surface hydrology or contamination	• An approximate 2.2 ha area of high suitability habitat for troglofauna has been avoided within the proposed topsoil stockpile area. • Avoidance of other indirect impacts to troglofauna is not possible for this Proposal.	• Groundwater drawdown will be minimised to that which is required for implementation of the Proposal. • Hydrocarbons, chemicals, and waste will be disposed of in accordance with legal requirements to minimise the potential for contamination of troglofauna habitat. Surface water discharge from hydrocarbon storage or PAF areas will be avoided as far as practical. • Water quality of dewatering surplus will		Habitat degradation is expected to be minimal, temporary and highly localised. Habitat degradation is not expected to represent a significant impact to troglofauna, given the extent of high and medium suitability habitat remaining in areas outside the impact areas.

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		be monitored prior to discharge. • Topsoil stockpile heights will be limited to less than 2 m.		

9.4.5 Assessment and significance of residual impact to troglofauna

9.4.5.1 Direct impacts to troglofauna

9.4.5.1.1 Removal of troglofauna habitat

9.4.5.1.1.1 Main Range

Excavation for the development of mine pits within the Main Range will result in the removal of up to 30% of medium and high suitability troglofauna habitat which represents a moderate risk of impact (Biologic 2021c; Table 9-7). However, it should be noted that the removal of AWT habitat within the pits of the Main Range does not appear to affect the wider continuity and connectivity of suitable habitat outside the pit boundaries, with almost 70% of the suitable AWT habitat being retained in the Main Range and Avon West areas (Biologic 2021c). Following mining, high and medium suitability habitat will remain in areas surrounding the proposed pits throughout the Main Range, which will remain connected to similar habitats in Avon West (Figure 9-8). Suitable habitat remaining within the Main Range and at Avon West will continue to provide suitable refugial habitat for troglofauna species affected by the proposed mining (Biologic 2021c).

Monitoring at other mines where troglofauna habitat has been removed indicates that communities continue to exist adjacent to active mining areas as well as post operations. For example, a viable troglofauna community remains at Rio Tinto's Mesa A Mine Area despite ongoing mining and removal of more than 20% of the available habitat within the mesa landform over the last ten years (Rio Tinto 2018).

Overall, given that a significant proportion (70%) of suitable, connected habitat will remain throughout the Main Range and Avon West, implementation of the Proposal is not expected to significantly affect the ecological integrity of the troglofauna habitat within the Development Envelope. It is expected that a viable troglofauna community will continue to exist within the Development Envelope during and after mining and impacts are therefore not expected to be significant.

9.4.5.1.1.2 Crescent Moon

The development of the pit at Crescent Moon will result in the removal of up to 48% of medium and high suitability troglofauna habitat which represents an initial medium level of impact, prior to any mitigation measures (Table 9-7; refer to Section 9.4.3.1.1). The removal of suitable AWT habitat within the pits at Crescent Moon considerably reduces the thickness of the suitable habitat at the top of the mesa, but the remaining habitat will continue to be connected and continuous throughout its original extent (Biologic 2021c). The pre-mining suitable habitat at Crescent Moon is already relatively thin, averaging approximately 15 m to 24 m thick. Post-mining, the suitable remnant habitat will be reduced to 5 -15 m thick (Biologic 2021c). Although there is no clear threshold for an appropriate thickness of remnant habitat for troglofauna, temperature and humidity studies in the Robe Valley Mesas indicate that a minimum thickness of 6 m of pisolitic CID is required to buffer temperature and humidity fluctuations, and therefore habitat thicker than 6m should provide suitably stable conditions for troglofauna (Biologic 2021c). Although limited data is available, the pisolith habitat at Crescent Moon is highly analogous to the CID habitat at Robe Valley Mesas; therefore, it may be reasonable to infer that any remnant habitat less than 6 m thick will be less suitable for troglofauna (Biologic 2021c).

Further areas of potentially suitable habitat have been inferred to occur west of Crescent Moon (Figure 9-7 and Figure 9-8); however, these areas have not been sampled to date, and so it is unknown if these areas support the same troglofauna habitat as Crescent Moon (Biologic 2021c).

These western areas have the potential to continue to provide suitable refugial habitat for troglofauna species impacted by mining activities at Crescent Moon. These areas have not been included in the

volumetric calculations of habitat loss/ retention shown in Table 9-7. Approximately 52% of the modelled habitat volume will remain after mining at Crescent Moon; however, given the potential for further suitable AWT habitat to the west, this is likely to be an underestimation.

To further mitigate impacts to troglofauna habitat, the Proponent proposes to only mine the eastern section of Crescent Moon, until such a time that the Proponent can demonstrate that the troglofauna habitat of Crescent Moon occurs in areas outside those to be impacted (refer to Section 9.4.4; Figure 9-7). At least 50% of surface area of the habitat will be retained within a Provisional Mining Exclusion Zone, located in the western portion of Crescent Moon (Figure 9-7). This area will continue to provide high and medium suitability habitat for troglofauna that will remain connected to the post-mining troglofauna habitat remaining below the proposed pit within the eastern section of Crescent Moon. These areas will provide refugial habitat with a thickness between 10m - 24m which will minimise the risk of desiccation impacts (Biologic 2021c). The Troglofauna Habitat Investigation Area (Figure 9-7) will be targeted for further habitat modelling and sampling work to establish the wider local connectivity of suitable habitat as occurs within the proposed impact areas as Crescent Moon. Pending further survey work, these areas are anticipated to continue to provide refugial habitat that is likely to be connected to the post-mining habitat remnants at Crescent Moon.

This strategy is proposed until such time as the Proponent can provide evidence to demonstrate the occurrence of connected habitat outside the direct and indirect impact areas of Crescent Moon. It is expected that the potential impacts from any further mining of the Crescent Moon mesa will be mitigated by the retention of a similar or greater proportion of additional suitable habitat, connected to the mesa, to be demonstrated by further investigations.

Based on the above strategy and the management measures proposed in Section 9.4.4, the potential impacts to the troglofauna assemblage within Crescent Moon can be managed to meet the EPAs objective for this factor and are not expected to be significant.

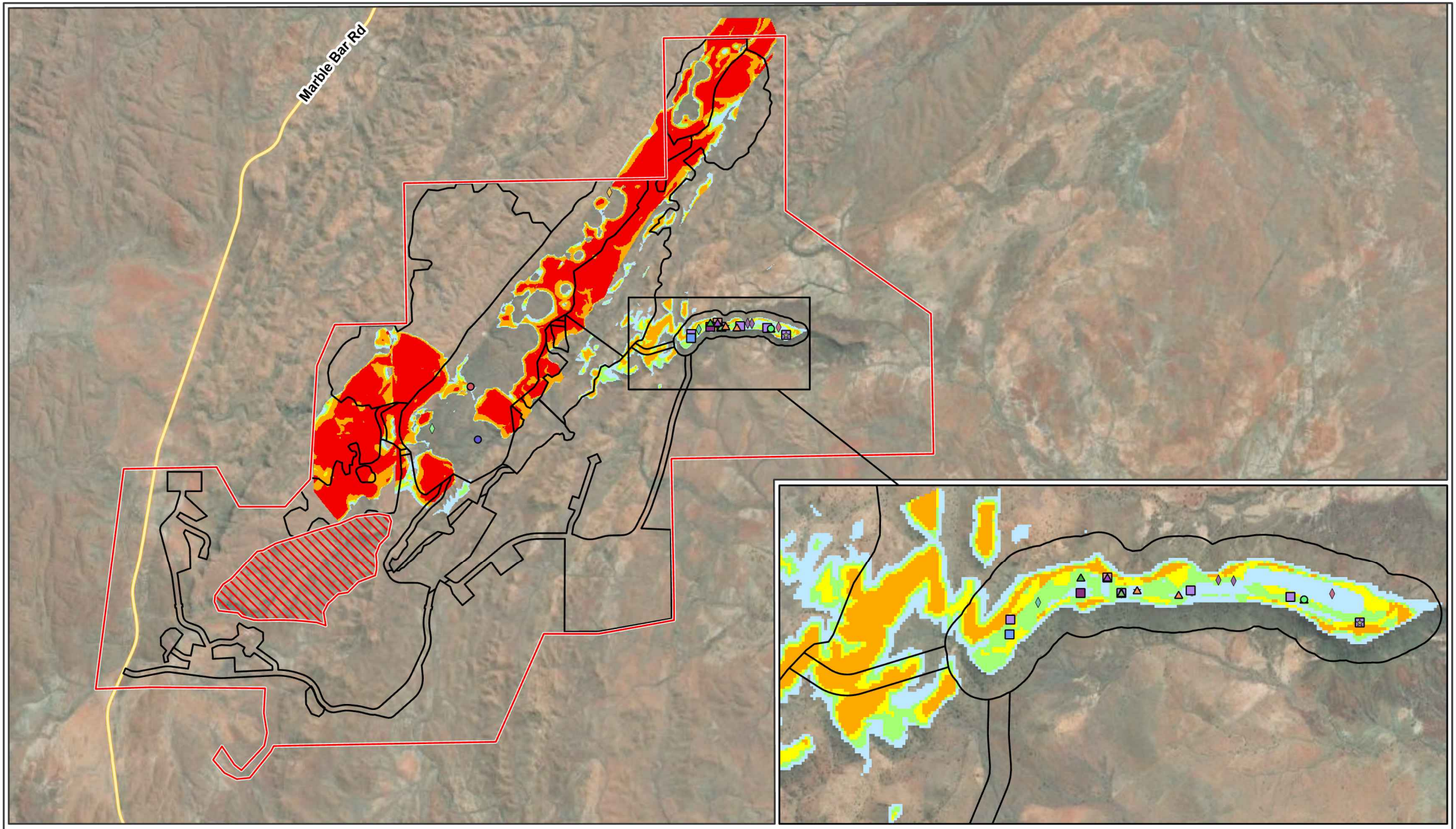

Figure 9-8: Remaining troglofauna habitat post-mining (excluding mitigation strategy)

Conceptual Footprint
Significant Fauna Exclusion Zone

Habitat Thickness
Low (0.0m-6m)
Low to Medium (6.01m-9m)
Medium to Low (9.01m-12m)
High (12.01m-33m)
Very High (33m +)

Troglofauna Species
Anillini sp. McP2
Armadillidae `sp. Biologic-ISOP031`
Atelurinae `sp. Biologic-ZYGE029`
Chilenophilidae sp. McP
Chthoniidae `sp. Biologic-PSEU043`
Cryptops `sp. Biologic-CHIL016`
Gnaphosidae `sp. Biologic-ARAN029`
Hanseniella `sp. Biologic-SYMP033`
Linyphiidae `sp. Biologic-ARAN026`
Oonopidae `sp. Biologic-ARAN025`
Palpigradi `sp. Biologic-PALP034`
Palpigradi `sp. Biologic-PALP035`
Pauropoda `sp. Biologic-PAUR023`
Pauropoda `sp. Biologic-PAUR024`
Pauropoda `sp. Biologic-PAUR025`
Pauropoda `sp. Biologic-PAUR041`
Pauropoda sp. McP
Pselaphinae sp. McP
Trinemura `sp. Biologic-ZYGE032`
Troglarmadillo`sp. Biologic-ISOP030`

0 500 1,000 2,000
Metres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

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9.4.5.1.2 Loss of troglofauna individuals

9.4.5.1.2.1 Main Range

Four troglofauna taxa are recorded only from impact areas within the Main Range at present, comprising (Table 9-9; (Biologic 2021c):

- Anillini `sp. McP2`
- Pselaphinae `sp. McP`
- Chilenophilidae `sp. McP`
- Pauropoda `sp. McP`.

All four species are singletons recorded only from proposed pits within the Main Range; however, all species were recorded in BIF or chert in the Paddy Market Formation which extends beyond the impact area to the south and west. Morphological ID could not align any of these species with any other specimens. Nevertheless, both Anillini `sp. McP2` and Pselaphinae `sp. McP could have a similar distribution to Anillini `sp. McP1` (based on similar taxonomic classification and general ecological characteristics), which was found outside of impact areas throughout the Main Range and at Crescent Moon (Biologic 2021c). No suitable surrogates were recorded in the Development Envelope for Chilenophilidae `sp. McP`. Pauropoda `sp. McP` was morphologically determined from earlier survey work and thus may represent one of the other Pauropoda taxa found outside the impact areas; however, this could not be confirmed due to a lack of genetic information (Biologic 2021c).

The four species recorded only from the proposed pits within the Main Range have been assigned as medium risk, due to the following (Table 9-9; Biologic 2021c):

- Each of the four troglofauna taxa were collected as singletons; however, given that they were recorded in habitat that extends beyond the area of impact, they can be inferred to also occur in habitat that remains outside of impacts.
- Habitat modelling and the occurrence of shared species demonstrates that suitable habitat is highly connected/ continuous inside and outside of the proposed pits along the Main Range.
- There are no potential habitat barriers within the Main Range that would be expected to limit the occurrence of these troglofauna species to the proposed pits. Faults occurring along the Main Range do not appear as barriers to troglofauna dispersal and may potentially increase habitat connectivity by promoting fracturing and weathering processes.
- Many other troglofauna species found within the Main Range occur more widely throughout the extent of suitable habitat at the Main Range and/ or at Avon West.
- Almost 70% of the suitable habitat AWT will be retained in the Main Range and Avon West, and it is reasonable to expect that these areas will continue to provide suitable refugial habitats for troglofauna species affected by the proposed mining.

Given the above mitigating factors and the management measures proposed in Section 9.4.4, the potential impacts to the troglofauna assemblage within the Main Range can be managed to meet the EPAs objective for this factor and are not expected to be significant.

9.4.5.1.2.2 Crescent Moon

Fifteen troglofauna taxa are known only from the proposed Crescent Moon pit (Table 9-9; Biologic 2021c):

- Gnaphosidae `sp. Biologic-ARAN029`
- Oonopidae `sp. Biologic-ARAN025`
- Linyphiidae `sp. Biologic-ARAN026`

- Chthoniidae `sp. Biologic-PSEU043`
- Palpigradi `sp. Biologic-PALP034`
- Palpigradi `sp. Biologic-PALP035`
- *Trinemura* `sp. Biologic-ZYGE032`
- *Cryptops* `sp. Biologic-CHIL016`
- Pauropoda `sp. Biologic-PAUR023`
- Pauropoda `sp. Biologic-PAUR024`
- Pauropoda `sp. Biologic-PAUR025`
- Pauropoda `sp. Biologic-PAUR041`
- *Hanseniella* `sp. Biologic-SYMP033`
- Armadillidae `sp. Biologic-ISOP031`
- *Troglarmadillo* `sp. Biologic-ISOP030`.

Nine species are singletons whereas the remaining six species were collected from either two or five sites within Crescent Moon, within pisolith/CID habitat (Table 9-9; Biologic 2021c). The wider extent and connectivity of this habitat type beyond the proposed pit at Crescent Moon is unknown, although habitat modelling suggested similar habitats may occur to the west between Crescent Moon and the Main Range (Biologic 2021c). Molecular ID could not align any of these species with other specimens and no surrogates are available to infer potential distributions (Biologic 2021c).

With no mitigation strategy, risks to all 15 species would be considered high due to the following (Biologic 2021c):

- Aside from a few locally widespread species, the troglofauna assemblage at Crescent Moon appears unique and mostly contains species that have not been found to date in the Main Range, Avon West, or more widely in the region.
- The suitable habitat at Crescent Moon (pisolith) is geologically distinct, and physically separated from other suitable habitats in the Main Range by major faults and topographical influences (mesa landforms).
- The proposed pit at Crescent Moon encompasses almost the entire area, although not the entire thickness, of suitable pisolith habitat.
- The proposed mining at Crescent Moon will leave behind a thin remnant habitat ranging from approximately 5 m to 15 m thick. Whilst habitat greater than 6 m thick is likely to provide suitable troglofauna habitat, habitat less than 6 m thickness is less likely to be suitable and may be subject to desiccation effects.
- 3D modelling and surface geology mapping indicates that potentially connected suitable habitats nearby to the east and west, but these areas have not been sampled to confirm the occurrence of the same troglofauna assemblage as found at Crescent Moon.
- Although 52% of the suitable habitat AWT will be retained in the Crescent Moon area (Table 9-9) it remains uncertain whether the remnant habitat will continue to be suitable for troglofauna species following the proposed mining, due to remaining thickness.

Despite the above, the retention of 52% of suitable AWT habitat at Crescent Moon is not inclusive of potentially suitable, connected habitats to the east and west. This is therefore likely to be an underestimation of the suitable AWT habitat that will remain. However, given the lack of knowledge surrounding the occurrence of these species in areas outside those to be impacted, impacts to these 15 troglofauna species are considered potentially significant.

In order to reduce impacts to the troglofauna assemblage of Crescent Moon, the Proponent proposes to only mine 50% of the eastern section surface area of Crescent Moon (refer to Section 9.4.4). Under this scenario, the following six species will be directly impacted by the Proposal (Figure 9-7):

- Pauropoda 'sp. Biologic-PAUR024' – both known records impacted, but suitable habitat remains
- Pauropoda `sp. Biologic-PAUR025`– both known records impacted, but suitable habitat remains
- *Hanseniella* `sp. Biologic-SYMP033`– also recorded in PMEZ, suitable habitat remains
- Armadillidae `sp. Biologic-ISOP031'– singleton impacted, suitable habitat remains
- Linyphiidae `sp. Biologic-ARAN026`– also recorded in PMEZ, suitable habitat remains
- *Trinemura* `sp. Biologic-ZYGE032`– singleton impacted, suitable habitat remains

Impacts to these species will be reduced through the retention of suitable troglofauna habitat in pisolith/CID geologies beneath and alongside the Crescent Moon pit. This remaining habitat will continue to be connected to a large, relatively undisturbed habitat remnant within the Provisional Mining Exclusion Zone in the western section of Crescent Moon (Figure 9-7 and Figure 9-8).

If, and when, the Proponent can demonstrate that the suitable troglofauna habitat occurring at Crescent Moon extends further into areas beyond the proposed impacts and can demonstrate that the same troglofauna habitat occurs in these areas beyond impacts, then the Provisional Mining Exclusion Zone may be reduced or removed to allow further mining at the Crescent Moon mesa. It is expected that the potential impacts from any further mining of the Crescent Moon mesa will be mitigated by the retention of a similar or greater proportion of additional suitable habitat, connected to the mesa, that contains the same troglofauna assemblage, to be demonstrated by further investigations.

Under this scenario, direct impacts to the troglofauna assemblage of Crescent Moon are not expected to be significant.

9.4.5.2 Indirect impacts to troglofauna

Troglofauna are expected to continue to utilise habitat in or below the proposed waste dumps within the Main Range, as has been observed from recent troglofauna sampling at other mining operations (e.g. Rio Tinto's Mesa A and Mesa J; Rio Tinto 2018); however, the extent of utilisation of such disturbed areas is unknown.

Similarly, troglofauna are expected to continue to utilise the habitats beneath the topsoil stockpile and waste dump located at Avon West. Indirect impacts associated with the placement of the topsoil stockpile or waste dumps will be temporary and are expected to be minimal, given that the stockpile will be less than 2 m in height and will be re habilitated at closure. The avoidance of approximately 2.2 ha (of the surface area) of high suitability troglofauna habitat within the stockpile will further assist in minimising indirect impacts associated with habitat degradation. In addition, troglofauna species recorded in this location were recorded from multiple sites and are unlikely to be restricted to the area occupied by the proposed topsoil stockpile. Areas of high suitability habitat within the exclusion zone and in areas that extend beyond the stockpile boundary, will continue to provide refuge for troglofauna, should any indirect impacts occur to the habitats present directly beneath the stockpile. Any potential indirect impacts will be minimal in magnitude, temporary, and unlikely to significantly impact troglofauna habitat or species values.

The estimated extent of indirect impacts to potential subterranean fauna habitat from vegetation removal or changes to infiltration from placement of mineral waste dumps and/or topsoil stockpiles, is estimated to be approximately 43% of the inferred extent of suitable habitat within the Development Envelope. Areas of suitable habitat outside of this disturbance footprint (i.e. 57% of the inferred extent of habitat) would be expected to remain unaffected by these indirect impacts (note that the inferred extent of suitable habitat is limited and will represent an underestimation of the actual habitat present).

Given that a considerable proportion of suitable troglofauna habitat exists outside the proposed direct and indirect impact areas, and that rehabilitation of disturbed areas outside pit voids will be undertaken, impacts of vegetation clearing, and changes to surface infiltration or contamination from waste dumps or stockpiles are expected to be localised and not expected to significantly degrade troglofauna habitat.

Risks associated with blasting activities and vibration are generally considered minor but are difficult to measure and assess. Investigations at other mines in the Pilbara suggest that vibration and blasting have minimal effect on the integrity of geological structures (and therefore, troglofauna habitat) even as close as 5 m away from the pit face (i.e. at Rio Tinto's Mesa A mine; Rio Tinto 2018). Therefore, the risks from vibration associated with blasting or other mining activities included in this Proposal are considered to be minor.

It is unlikely that the potential indirect impacts from changes in surface hydrology or groundwater drawdown would cause a significant risk of desiccation to the suitable troglofauna habitat remaining within the Main Range (Biologic 2021c). The fractured rock aquifer within the Main Range is already relatively deep, therefore much of the pre-mining troglofauna habitat is unlikely to derive much of its moisture from groundwater. The Avon West area is largely outside of the direct areas of groundwater drawdown and groundwater levels are not expected to decline significantly outside the pit areas as a result of the proposal. A petrology report (Teale 2011) found that the rocks within the Main Range retained a high degree of moisture within fractures, pore spaces, and cavities, even despite additional efforts to dry-out the core samples. Any decline in water infiltration due to waste dumps, infrastructure and/or stockpiles may be offset by a decline in evaporative losses due to the change in land surface coverage. In addition, approximately 57% of the remaining habitat will not be subject to land surface changes from waste dumps or infrastructure, and infiltration would be expected to be unchanged. The indirect impacts of desiccation are therefore not expected to significantly affect the suitable habitats remaining outside of the direct impact areas at the Main Range, or the suitable habitats at Avon West (Biologic 2021c).

Given that no drawdown or BWT mining will occur at Crescent Moon, impacts associated with groundwater drawdown will not occur; however, the proposed mining and land surface change has the potential to increase the rate of desiccation of the subterranean environment. Following mining, the remaining suitable habitat at Crescent Moon will range from approximately 5 m to 15 m thick, which is considered to be relatively thin. Remnant habitat less than 6 m thick could be highly susceptible to desiccation impacts at Crescent Moon, and potentially unsuitable for troglofauna colonisation (Biologic 2021c). The retention of connected, post-mining troglofauna habitat with suitable habitat within the Troglofauna Habitat Investigation Area (refer to Section 9.4.3.1.1), along with management procedures to reduce the risk of subterranean habitat degradation from changes in surface hydrology are expected to reduce this risk.

Hydrocarbon storage and spill management procedures are expected to effectively mitigate the risk of hydrocarbon or chemical contamination of troglofauna habitat. The Proponent has well established strategies for the management of wastes at its Pilbara operations to ensure that risk of contamination of soil or groundwater is minimised. Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements.

9.4.6 Environmental outcome

The predicted impacts to troglofauna from the Proposal after applying the mitigation hierarchy (avoid, minimise, rehabilitate) are:

9.4.6.1 Main Range

- Removal of up to 30% of suitable AWT troglofauna habitat within the Main Range.
- Retention of approximately 70% of suitable AWT troglofauna habitat within the Main Range (including Avon West).
- Direct impacts to four troglofauna taxa considered at medium risk of impact from the Proposal including:
    - Anillini `sp. McP2`
    - Pselaphinae `sp. McP`
    - Chilenophilidae `sp. McP`
    - Pauropoda `sp. McP`.
- No significant residual impact to troglofauna taxa and/or troglofauna habitats within the Main Range due to the following:
    - 3D habitat modelling has confirmed that suitable habitat is highly connected/ continuous inside and outside of the proposed pits within the Main Range.
    - There are no potential habitat barriers in the Main Range that would be expected to limit the occurrence of these troglofauna species to the proposed pits.
    - Many other troglofauna species found within the Main Range occur more widely throughout the extent of suitable habitat at the Main Range and/ or at Avon West.
    - Almost 70% of the suitable habitat AWT will be retained in the Main Range and Avon West, and it is reasonable to expect that these areas will continue to provide suitable refugial habitats for troglofauna species affected by the proposed mining.

9.4.6.2 Crescent Moon

- Removal of up to 48% of suitable AWT troglofauna habitat within Crescent Moon.
- Retention of approximately 52% of suitable AWT troglofauna habitat within Crescent Moon, which is likely to represent an underestimation of the suitable habitat that will remain post-mining within the wider area.
- Fifteen troglofauna taxa are known only from the proposed Crescent Moon pit. With no mitigation strategy, risks to all 15 species would be considered high. Therefore, in order to address this unacceptable impact, the Proponent commits to mining only 50% of the surface extent within Crescent Moon, until such a time that it can be demonstrated that the troglofauna habitat of Crescent Moon occurs in areas outside those to be impacted either through additional habitat modelling and/or additional sampling.
- Under this scenario, the known records of the following six troglofauna species will be directly impacted by the Proposal at Crescent Moon:
    - Pauropoda 'sp. Biologic-PAUR024`
    - Pauropoda `sp. Biologic-PAUR025`
    - *Hanseniella* `sp. Biologic-SYMP033`
    - Armadillidae `sp. Biologic-ISOP031`
    - Linyphiidae `sp. Biologic-ARAN026`
    - *Trinemura* `sp. Biologic-ZYGE032`
- However, the impacts in this area will be mitigated by the continued presence of medium and high suitability habitat remaining post-mining, that is connected to habitat in the western section of Crescent Moon and extends into areas outside the impact area.
- If, and when, the Proponent can demonstrate that the suitable troglofauna habitat occurring at Crescent Moon extends further into areas beyond the proposed impacts and can demonstrate that similar troglofauna habitat occurs in these areas beyond impacts, then the Provisional Mining

Exclusion Zone may be reduced or removed to allow further mining at the Crescent Moon mesa. It is expected that the potential impacts from any further mining of the Crescent Moon mesa will be mitigated by the retention of a similar or greater proportion of additional suitable habitat connected to the mesa, to be demonstrated by further investigations. On this basis, direct impacts to the troglofauna habitat of Crescent Moon are not expected to be significant.

9.4.7 Conclusion

Through the implementation of the EPA mitigation hierarchy and the proposed Crescent Moon strategy, the residual impacts of the Proposal to troglofauna can be managed to meet the EPA's objective for subterranean fauna.

9.5 Stygofauna

9.5.1 Stygofauna habitat

The groundwater habitat in the McPhee Creek deposit forms unconfined aquifers with high secondary permeability associated with the BIF and fractured bedrock aquifers of the Corboy Formation (ELA 2013). Although the geological strata is relatively continuous, water level is such that the groundwater bodies appear to form discrete aquifers that are relatively isolated. Little is known about their extent and whether or not fault zones affect groundwater flow, consequently prohibiting fauna dispersal within these "pod-like" aquifers (Subterranean Ecology 2012).

Within the Paddy Market Formation across the Main Range, average groundwater levels are approximately 50-65 mbgl, whereas at Avon West the water table is higher, averaging 30 mbgl (Figure 6-7 and Figure 9-9). Depth to groundwater is recognised as a potential constraint to stygofauna abundance and diversity and across the region, groundwater habitats deeper than 30 mbgl in the Pilbara have typically recorded fewer stygofauna species, or lower stygofauna abundance, than shallower groundwater habitats (Halse et. al. 2014). Given that the depth to groundwater throughout the majority of the Development Envelope averages 50 m, this could be a factor in the reduced abundance and diversity of stygofauna found to occur beneath the Main Range.

Groundwater physico-chemistry within the Development Envelope suggests that groundwater is within the habitable ranges for stygofauna (Subterranean Ecology 2012); however, given the low number of stygofauna specimens collected (despite extensive sampling), stygofauna are sparsely distributed and relatively depauperate in the Main Range and Avon West (refer to Section 9.5.2).

9.5.2 Stygofauna records

The combined stygofauna results (including current and previous surveys of the Development Envelope) recorded a 10 stygofauna taxa and four indeterminate taxa from four higher order groups: Oligochaeta, Bathynellacea, Cyclopoida, and Harpacticoida (Biologic 2021c). The indeterminate taxa were either recorded outside of the direct impact areas or are likely to represent morphospecies recorded outside of direct impact and are not considered further in this report (Biologic 2021c).

Of the 10 stygofauna taxa recorded, six taxa represent widespread species, and four taxa are unique lineages (Table 9-11). Very few specimens were recorded from the Main Range, with most specimens being collected from alluvial areas at Crescent Moon and/or areas outside the Conceptual Footprint (Table 9-11 and Figure 9-9).

None of the stygofauna taxa recorded in the Development Envelope, are listed or recognised as conservation priorities under state or federal legislation (Biologic 2021c).

Table 9-11: Stygofauna species recorded within the Development Envelope

Taxon	Main Range	Crescent Moon	Outside Impact	Linear range	Ecological and SRE status	Identification and distribution comments
Oligochaeta						
Enchytraeidae `sp. Biologic-OLI021`		1		>100	Stygoxene, Widespread	Molecular ID matched this species to a specimen from near Newman.
Enchytraeidae `sp. Biologic-OLI022`		1	7	4.98	Stygoxene, unlikely SRE	Molecular ID showed this species to be a unique lineage. Known from three sites outside of direct impact.
Enchytraeidae `sp. E6`		2		>100	Stygoxene, Widespread	Molecular ID matched this species to a widespread species clade.
Enchytraeidae `sp. E13`	9			>100	Stygoxene, Widespread	Molecular ID matched this species to a specimen from Weelamurra Creek.
Phreodrilidae `sp. Biologic-OLIG059`			1	0	Stygofauna, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of direct impact.
Bathynellacea						
Bathynellidae `sp. McP`			2	0	Stygobite, Potential SRE	Morphological ID. Known from one site outside of direct impact.
nr *Kimberleybathynella* `sp. McP`			2	0	Stygobite, Potential SRE	Molecular ID showed this species to be a unique lineage. Known from one site outside of direct impact.
Cyclopoida						
Diacyclops humphreysi			35	>100	Stygoxene, Widespread	Widespread species known from beyond the Study Area.
Microcyclops varicans			601	>100	Stygoxene, Widespread	Widespread species known from beyond the Study Area.
Pescecyclops `sp. WAM-CYLP001`			1	>100	Stygoxene, Widespread	Molecular ID matched this species to a specimen from near Paraburdoo.

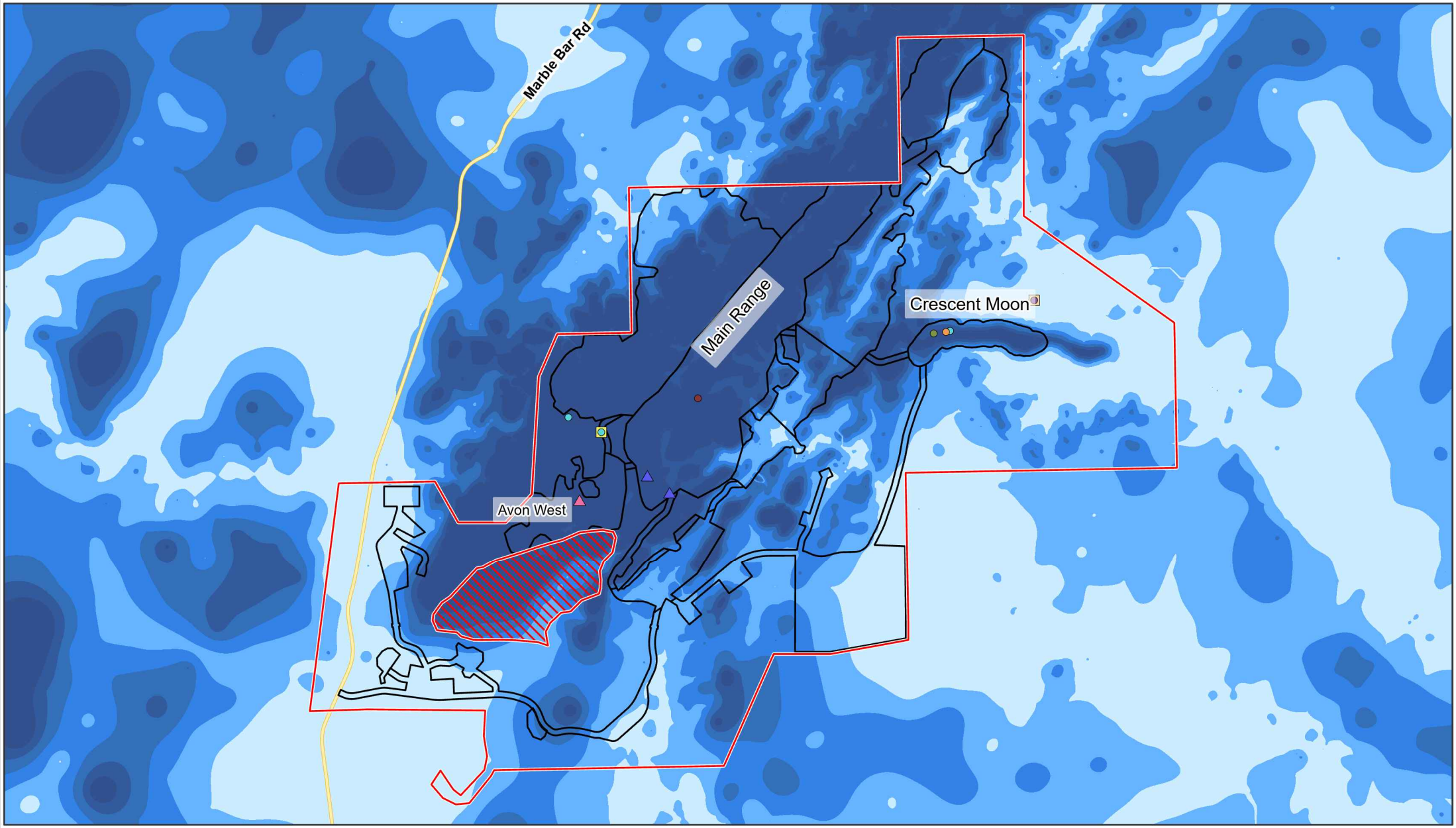

Figure 9-9: Stygofauna records and depth to groundwater within the Development Envelope

Conceptual Footprint
Development Envelope
Significant Fauna Exclusion Zone

Depth to Groundwater (GHD Model, ELA Interpretation 2020)
0m - 10m
10m - 20m
20m - 30m
30m - 40m
40m - 50m
50m - 70m
70m - 120m

Stygofauna Species
Bathynellidae sp. McP
Diacyclops humphreysi
Enchytraeidae sp. Biologic-OLIG021
Enchytraeidae sp. Biologic-OLIG022
Enchytraeidae sp. E6
Enchytraeidae sp. E13
Microcyclops varicans
Pescecyclops sp. WAM-CYLP001
Phreodrilidae sp. Biologic-OLIG059
nr *Kimberleybathynella* sp. McP

0 0.5 1 2
Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 12/04/2022

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9.5.3 Potential environmental impacts to stygofauna

9.5.3.1 Direct impacts to stygofauna

Implementation of the Proposal will potentially result in the following direct impacts to stygofauna:

- Removal of stygofauna habitat from BWT mining and/or groundwater abstraction
- Loss of stygofauna individuals.

Some stygofauna habitat will be permanently lost through BWT mine excavation within the proposed pit areas of the Main Range.

Implementation of the Proposal will involve dewatering of the ore body. Groundwater abstraction is described in further detail in Section 8.4. Groundwater abstraction will result in loss of stygofauna habitat within the groundwater drawdown contour areas within the Main Range.

None of the stygofauna taxa recorded are only known from within the Conceptual Footprint, with all species being either widespread or occurring in areas outside the direct impact area. As such, loss of stygofauna individuals is not considered to represent a potential impact and has not been included any further in this assessment.

Mining at Crescent Moon will be AWT and therefore no direct impacts on stygofauna habitat through either excavation or dewatering will occur.

9.5.3.2 Indirect impacts to stygofauna

The potential indirect impacts to stygofauna are mainly associated with the degradation habitat from clearing, changes in surface hydrology or contamination and are similar to those described for troglofauna.

Clearing of vegetation and placement of mineral waste material may lead to a reduction in organic inputs and potentially a localised reduction of surface water infiltration which can lead to degradation of stygofauna habitat.

The estimated extent of indirect impacts to potential stygofauna habitat from vegetation removal or changes to infiltration from placement of mineral waste dumps, is estimated to be approximately 38.2 % of the surface extent of mapped habitats within the Development Envelope.

Alterations to surface hydrology and increases in surface erosion can potentially reduce groundwater quality and degrade suitable stygofauna habitat. The potential for groundwater to become contaminated can also occur from the placement of waste dumps, the disposal of waste fines, exposure of PAF material, storage of PAF in waste dumps, post-closure formation of pit lakes and/or handling of hazardous materials or wastes. These activities could potentially result in harmful substances infiltrating into the subterranean environment, thereby making suitable stygofauna habitat uninhabitable.

9.5.3.3 Cumulative impacts to stygofauna

Given that there are no other mining projects within 20 km of the Proposal, no cumulative impacts to stygofauna are expected to occur.

9.5.4 Mitigation

During Proposal design, the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to avoid and minimise potential impacts of the Proposal to stygofauna and associated environmental values as far as practicable.

Suitable stygofauna habitat mainly occur outside of the proposed impact areas, where the majority of stygofauna taxa were recorded; however, impacts to stygofauna habitats and assemblages will be further minimised through the following mitigation strategies:

- Groundwater drawdown will be limited to that which is required for implementation of the Proposal
- Clearing will be minimised to only that required for implementation of the Proposal
- Hydrocarbon management measures will minimise potential for contamination of subterranean fauna habitats

Table 9-12 summarises the mitigation measures that will be applied to the Proposal for stygofauna.

Table 9-12: Application of mitigation hierarchy for stygofauna

Potential impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: removal of stygofauna habitat	• Avoidance of BWT mining is not possible for this Proposal	• BWT mining will be minimised to that which is required for implementation of the Proposal.	N/A	• There will be no direct impacts to stygofauna associated with habitat removal from BWT mining as no, or very little, suitable habitat occurs within the areas proposed for BWT mining.
Direct impact: loss of stygofauna habitat through groundwater abstraction	• Avoidance of groundwater abstraction is not possible for this Proposal	• Groundwater drawdown will be minimised to that which is required for implementation of the Proposal.	N/A	• There will be a reduction in potential stygofauna habitat within the proposed pits due to groundwater abstraction; however, this is expected to have little impact on stygofauna given the lack of stygofauna specimens occurring in these areas.
Indirect impacts: degradation of stygofauna habitat from clearing, vibration, changes in surface hydrology or contamination	• Avoidance of indirect impacts to stygofauna habitat is not possible for this Proposal.	• Hydrocarbon management measures will minimise the potential for contamination of stygofauna habitat. • Surface water discharge from hydrocarbon storage or PAF areas will be avoided as far as practical. • Monitor water quality of dewatering surplus prior to discharge.	• Areas that are no longer in use will be rehabilitated as soon as practicable which will assist in re-establishing nutrient flows into the subterranean environment.	• Indirect impacts associated with habitat degradation will be highly localised and minimal.

9.5.5 Assessment and significance of residual impact to stygofauna

9.5.5.1 Direct impacts to stygofauna

9.5.5.1.1 Removal of stygofauna habitat

Groundwater habitats within the proposed pit areas at Main Range appear to form discrete pod like aquifers which have remained relatively isolated from surrounding aquifers and do not appear to support a diverse stygofauna assemblage. Suitable stygofauna habitat occurs mainly throughout the alluvial aquifer systems within Avon West and to the north of the Crescent Moon deposit, outside of the proposed impact areas. No stygofauna were recorded from the Nicholson or Ord impact areas within the Main Range, and only two widespread species (i.e. with a linear range over 100 km) were recorded from the southern boundaries of the Avon pit and Murray Pit within the Main Range (Biologic 2021c; Table 9-11; Figure 6-14. Areas of suitable stygofauna habitat will persist outside of the proposed impact areas at Avon West, and to the north of the Crescent Moon deposit where the majority of stygofauna taxa were recorded.

Given the low number of stygofauna recorded, the removal of potential stygofauna habitat within the Main Range is not expected to represent a significant impact. No removal of habitat will occur at Crescent Moon as mining is AWT.

9.5.5.2 Indirect impacts to stygofauna

The potential indirect impacts to stygofauna are mainly associated with the degradation of habitat from a reduction in surface infiltration, changes in surface hydrology or contamination as a result of vegetation clearing, placement of waste dumps, the disposal of waste fines, exposure of PAF material, storage of PAF in waste dumps, post-closure formation of pit lakes and/or handling of hazardous materials or wastes. However, given the lack of stygofauna assemblage present within the impact areas, any indirect impacts are expected to be minimal and not significant.

9.5.6 Environmental outcome

The predicted impacts to stygofauna from the Proposal after applying the mitigation hierarchy (avoid, minimise, rehabilitate) are:

- No direct impacts to stygofauna associated with habitat removal from BWT mining as no, or very little, suitable habitat occurs within the areas proposed for BWT mining.
- A reduction of potential stygofauna habitat within the proposed pits is not considered to be significant given the lack of stygofauna specimens occurring in these areas.
- No significant impact to stygofauna from indirect impacts associated with habitat degradation which will be highly localised and minimal.
- Implementation of the Proposal can meet the EPA's objective for stygofauna.

9.5.7 Conclusion

The residual impacts of the Proposal to stygofauna are expected to meet the EPA's objective for subterranean fauna and the Proponent considers that the residual impact will not be significant.

10 Social Surroundings

10.1 EPA environmental factor objective

The EPA objective for the Social Surroundings factor is *to protect social surroundings from significant harm* (EPA 2021c).

Social Surroundings is defined (EPA 2016b) as 'The social surroundings of man are his aesthetic, cultural, economic, and social surroundings to the extent that those surroundings directly affect or are affected by his physical or biological surroundings'.

10.2 Relevant policy and guidance

The relevant policy and guidance for Social Surroundings are described in Table 10-1.

Table 10-1: Relevant Policy and Guidance for Social Surroundings

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
Environmental Protection Authority	
Instructions on how to prepare an Environmental Review Document (EPA 2021d)	Considered during the development of this document
Statement of Environmental Principles, Factors and Objectives (EPA 2021c)	
Environmental Factor Guideline: Social Surroundings (EPA 2016b)	Considered in the design (methods and approach) of the social surroundings surveys/consultation or previous guidance (if survey undertaken before current guidelines)
Other State or Commonwealth	
DMIRS Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines (DMIRS 2020c)	Considered in the development of this document and for the Mine Closure Plan (Appendix A)
Statutory Guidelines for Mine Closure Plans (DMIRS 2020b)	
Department of Aboriginal Affairs and Department of Premier and Cabinet, Aboriginal Heritage Due Diligence Guidelines, Version 3.0 (DPLH and DPC 2013)	Considered in the impact assessment for social surroundings
Quality Assurance Standard for Community and Stakeholder Engagement (IAP2 Federation 2015).	

10.3 Receiving environment

10.3.1 Location and adjacent land uses

The Proposal is located in a remote area of the Pilbara region in Western Australia, with the closest residential area being Nullagine townsite, located approximately 30 km south of the Development Envelope. Site access is via a private access road off Marble Bar Road.

Bonney Downs Station, a privately held pastoral lease, extends from south of Marble Bar to north of Newman along the Nullagine River and Marble Bar Road, and intersects with the southern

portion of the Development Envelope. The primary land use within the station is cattle grazing. Consultation with the Bonney Downs leaseholder is ongoing to ensure any concerns are understood and addressed as they arise. To date there has been no opposition to the Proposal by the leaseholder.

Three lower tributaries of the Nullagine River, including the McPhee Creek, Branch of McPhee Creek and Lionel Creek intersect the Development Envelope. The Nullagine River feeds into the culturally significant De Grey River and reaches the ocean approximately 70 km north northeast of Port Hedland.

The Proposal area is dominated by low rocky hills, and there are no significant landscape features such as mountain and peaks in proximity to the Development Envelope. The visual landscape of the region would generally be described as being natural in appearance, with localised areas of highly modified landscapes associated with mining activities.

10.3.2 Native Title

The Development Envelope is located entirely within the Nyamal Native Title Claim Area (WC 1999/008).

The Proponent has had a claim-wide agreement in place with the Njamal since December 2008. This agreement covers all areas over which a registered Native Title Claim exists. The agreement provides for:

- Consultation with the Njamal during preparation of a Public Environmental Review (PER)[1] including field trip if requested.
- Supply of environmental approvals reports/management plans.
- Annual inspection of mining operations and environmental management.
- Ongoing access to all areas within any mining lease.
- Provision of cultural awareness training (to be provided by Njamal).

To date, consultation has been undertaken through a Monitoring and Liaison Committee (MALC) between the Proponent / Njamal and through the conduct of heritage surveys. Engagements between the Proponent and Njamal have been focused on identifying the location and nature of Aboriginal heritage sites within and adjacent to the Development Envelope. The Proponent will continue to consult with the Njamal in relation to the development of the Proposal.

10.3.3 Aboriginal heritage values and cultural associations

10.3.3.1 Heritage sites

Archaeological and ethnographic surveys have been undertaken across the whole of the Development Envelope, with the full participation and involvement of the Njamal, to identify any sites that may constitute an Aboriginal site under the *Aboriginal Heritage Act 1972* (WA) (AH Act). Table 10-2 provides a summary of surveys and on-country consultation undertaken in the Development Envelope, involving the Traditional Owners.

[1] EPA guidance now refers to the preparation of an Environmental Review Document (ERD) with the term PER used to describe the assessment process. The Proponent has consulted with the Njamal during the preparation of this ERD.

Table 10-2: Summary of Aboriginal heritage surveys and on country consultation undertaken for the Proposal

Survey	Timing	Method	Archaeological (Arch)/ Ethnographic (Ethno)
Site Avoidance Survey, Nominated Areas within Atlas Iron Ltd.'s McPhee Creek Exploration Project (Big Island 2012a)	April 2012	Site Avoidance Survey (exploration)	Arch/Ethno
Heritage Assessment, Atlas Iron Limited's Proposed McPhee Creek Resource Areas and Water Bore Locations (Big Island 2012b)	July 2012	Heritage Assessment (resource areas & bores)	Arch/Ethno
Work Area Heritage Assessment, Atlas Iron Limited's Proposed McPhee Creek Additional Resource Areas and Water Bore Locations (Big Island 2012c)	August 2012	Work Area (additional resource areas & bores)	Arch
Work Area Heritage Assessment, Atlas Iron Limited's Proposed McPhee Creek Tenements E46/733 and E45/3559 (Big Island 2012d)	August 2012	Work Area	Ethno
Work Area and Work Program Archaeological Assessment, Extensions to McPhee West, Zone 3 and Crescent Moon Access, Atlas Iron Limited's McPhee Creek Project (E46/733 and E45/3559) (Big Island 2013a)	March/May/June 2013	Work Area and Work Program (extension and access areas)	Arch
Work Area Archaeological Assessment, Main Range and Northern Waste Dumps and Infrastructure – Trips 1, 2, 3 and 4 and Infrastructure Infill Area within Atlas Iron Limited's McPhee Creek Project (tenements E46/0733, E46/802) (Big Island 2013b)	June/July/Aug 2013	Work Area (Main Range, WRD & infrastructure)	Arch
Archaeological Work Area (Site Identification recording) Assessment, Atlas Iron Limited's McPhee Creek Project, North Western Waste Dump (E46/733 and M45/1243) (Big Island 2013c)	August 2013	Work Area	Arch
Archaeological Work Area (Site Identification recording) Assessment, Atlas Iron Limited's McPhee Creek Project, South West Mining and Transport Infrastructure (E46/733, E46/732 and M45/1243) (Big Island 2013d)	Aug/Sept 2013	Work Area	Arch
Archaeological Work Area (Site Identification recording) Assessment, McPhee Creek West – Waste Dump within Atlas Iron Limited's McPhee Creek Project (Tenements E46/733, M45/1243) (Big Island 2013e)	Aug/Sept 2013	Work Area	Arch

Survey	Timing	Method	Archaeological (Arch)/ Ethnographic (Ethno)
Work Area (Site Identification) Assessment, Atlas Iron Limited's McPhee Creek Project, Crescent Moon South and Tailings Storage Facility Survey Area (tenement M45/1243) (Big Island 2014a)	Sept 2013, March/May 2014	Work Area	Arch
Ethnographic Work Area Assessment at Site Identification level - McPhee Creek Resource Areas and Infrastructure (Big Island 2014b)	June 2014	Work Area	Ethno
Work Program Archaeological Assessment - Infrastructure Geotech, Tenements E46/733, E46/732 and E45/3559 (Big Island 2014c)	March 2014	Work Program	Arch
Work Program and Work Area (Site Avoidance Recording) Ethnographic Assessment, Infrastructure Geotech, Tenements E46/733, E46/732 and E45/3559 (Big Island 2014d)	March 2014	Work Program and Work Area	Ethno
Atlas Iron Limited's McPhee Creek Project: Site Identification Recording of McPhee Creek 60-13A, tenement M45/1243 (Big Island 2014e)	May 2014	Work Area	Arch
Archaeological and ethnographic site avoidance heritage survey of Atlas Iron's E 46/802 McPhee prospect (Terra Rosa)	August 2019	Work Area (access track)	Arch/Ethno
Results of the archaeological and ethnographic survey of Atlas Iron's McPhee Creek Project Area (AI169) (Terra Rosa)	November 2019, Feb/March 2020	Work Program	Arch/Ethno
Archaeological and ethnographic site avoidance heritage survey of AI182 within Atlas Iron's McPhee Creek project area (Terra Rosa 2021a)	May 2021	Work Area	Arch/Ethno
An archaeological and ethnographic site identification survey of AI183 within Atlas Iron's McPhee Creek Project Area (Terra Rosa 2021b)	June 2021	Site ID Work Area Assessment	Arch/Ethno
Assessment of the Social Surroundings Values within the proposed McPhee Creek Iron Ore Project area (Terra Rosa 2021c)	August 2021	On Country Social Surroundings Consultation	Ethno

Surveys undertaken to date have recorded numerous archaeological and ethnographic sites in the region, including artefact scatters, engravings, grinding patches, quarries, rock shelters, water sources and areas of ritual and mythological importance (Terra Rosa 2021).

A rich cultural landscape has been identified within and surrounding the Development Envelope. The majority (67) of the 83 potential sites within the Development Envelope, including those identified in Table 10-3, are artefact scatters and quarries. Sites within the Development Envelope are shown in Figure 10-1.

A desktop assessment of the 'Aboriginal Heritage Inquiry System' (DPLH 2021) has confirmed that six sites classified as 'Other Heritage Places' are located within the Development Envelope and have been lodged with the Department of Planning, Lands and Heritage (DPLH) (Table 10-3).

Table 10-3: Other Heritage Places located within the Development Envelope and lodged with DPLH

Name	ID	Type	Status
MCP-02-12	38324	Natural Feature	Lodged
MCP-03-12	38323	Natural Feature	Lodged
MCP-04-12	38322	Natural Feature	Lodged
MCP-14-12	35797	Artefacts / Scatter, Ceremonial, Quarry	Lodged
MCP-43-13A	35798	Engraving, Grinding Patches / Grooves	Lodged
MCP-44-13A	35799	Engraving, Grinding Patches / Grooves	Lodged

The heritage site types in the Development Envelope that have been described as being of key concern to the Njamal include:

- Walled Niche (potential burial) site
- Ngurrara sites
- Engraving and Grinding sites
- Yinta.

The term Ngurrara is a Njamal concept relating to a place you belong, or a place you don't leave. The phrase is used throughout the Pilbara and Western Desert with slight variations. When people speak of a Ngurrara it also incorporates a spiritual aspect, identifying a place as a focal place of cultural and spiritual significance. A Ngurrara was described as 'like a home, a place where the old people repeatedly came back to and where water and grinding would be found' (Terra Rosa 2021). Ngurrara sites largely consist of places of water (either permanent or semi-permanent) with grinding nearby where past generations of Njamal people have spent considerable time. Ongoing on-country consultation with the Njamal will confirm those sites considered Ngurrara sites, and appropriate management measures for these sites.

'Yinta' is a term used by Njamal and other socio-linguistic groups in the Pilbara to describe permanent water sources. It is also a term that incorporates a set of spiritual beliefs, customs and behaviours.

Surveys and on-country consultation to increase the Proponent's understanding of the sites within the Development Envelope, and inform the development of mitigation measures, are ongoing.

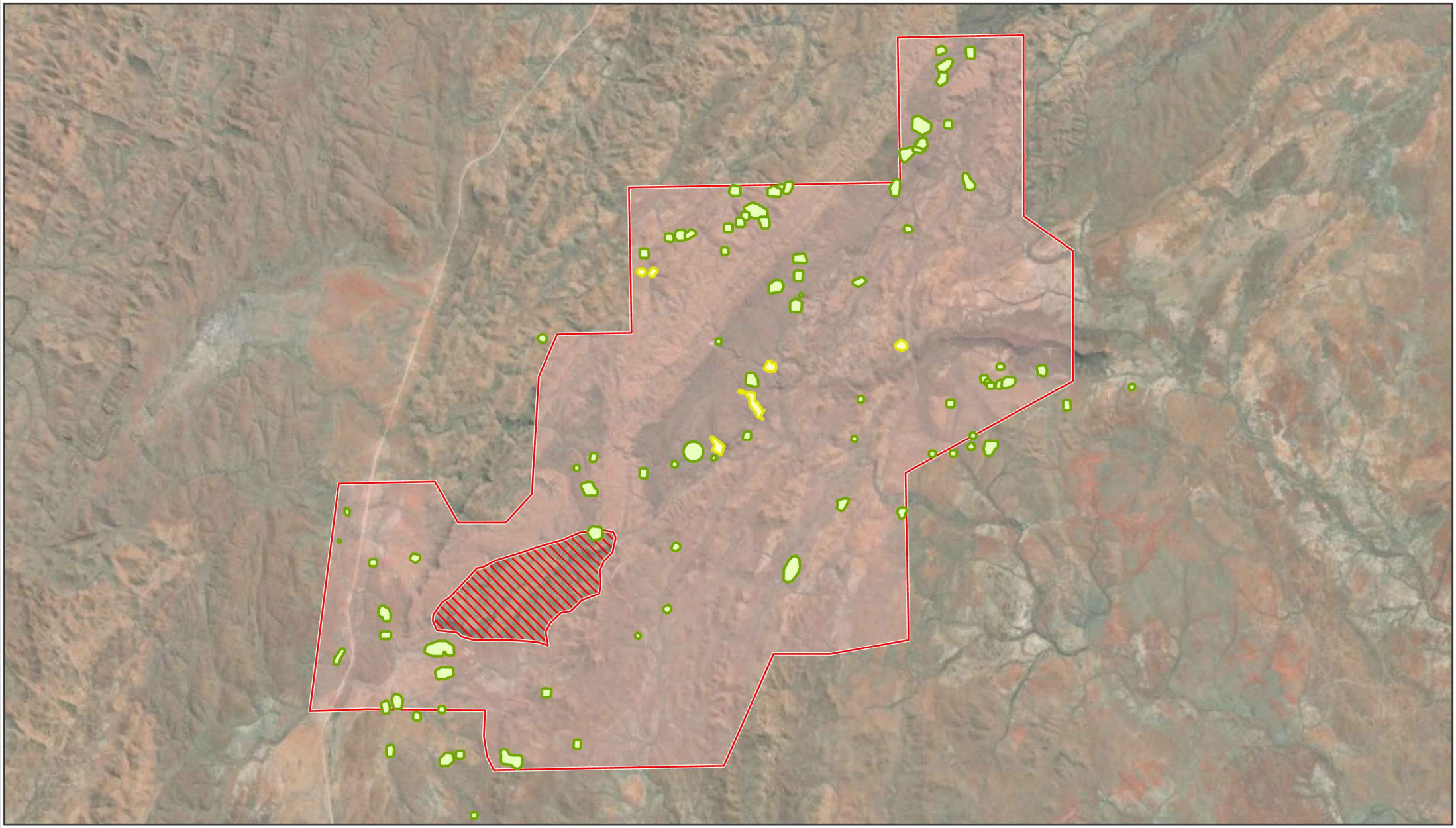

Figure 10-1: Sites of cultural and heritage significance within and adjacent to the Development Envelope

Significant Fauna Exclusion Zone

Heritage site status

Lodged

Potential Site

0 0.5 1 2

Kilometres

Datum/Projection:
GDA 1994 MGA Zone 51
Project: 15064-DD Date: 6/04/2022

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10.3.3.2 Social Surroundings Consultation

An on-country consultation trip was undertaken in August 2021 (Terra Rosa 2021), over a period of five days, involving representatives from the Njamal, Atlas Iron (the Proponent), Roy Hill, GHD and Terra Rosa consultants, with the following key objectives:

- Identify the key social, cultural and heritage values within the Development Envelope.
- Discuss the Proposal's potential impacts (direct and indirect).
- Determine the cultural significance of the Proposal's overall impacts.
- Identify any Njamal advice / recommendations regarding the management of impacts.

The following aspects of the Proposal were discussed with the Njamal to inform the design of the Proposal and the development of this ERD and preliminary Cultural Heritage Management Plan (CHMP; Appendix T):

- The Conceptual Footprint, including any sites likely to be directly impacted, and sites to be avoided (with a nominated avoidance buffer, Appendix T).
- The values associated with some of the sites likely to be directly impacted by the Proposal and options for the avoidance or minimisation of impacts, noting that subsequent on-country consultation, to assess each site in detail, would be undertaken prior to any application(s) under the AH Act.
- The values associated with sites potentially indirectly impacted by the Proposal (i.e. through fly rock, dust, changes to surface hydrology, changes to access or visual impact), options for the avoidance or minimisation of impacts, and relevant management measures.
- The values associated with the land in general in areas potentially impacted by the Proposal (including impacts to environmental values associated with dust, changes to surface hydrology, changes to groundwater, changes to access or visual amenity), options for the avoidance or minimisation of impacts, and relevant management measures.
- Other matters such as opportunities for indigenous employment and on-country knowledge transfer.

The Njamal were reassured that the completion of the Social Surroundings consultation, and any subsequent grant of State environmental approval, does not negate the need for additional approvals (including under the AH Act) prior to Proposal commencement.

While a significant body of survey and consultation has already occurred, to assist the Proponent in understanding the cultural heritage landscape and to assist Njamal in understanding the Proposal, consultation is recognised as an imperative and ongoing requirement for the life of the Proposal.

10.3.3.3 Cultural associations

During the on-country consultation trip in August 2021 (Terra Rosa 2021) discussions were held with the Njamal Traditional Owners in an effort to identify the cultural associations relevant to the Proposal. The Njamal outlined how Njamal people have traditionally used country in the McPhee Creek area, and it was noted that there was a differentiation between coastal Njamal people and inland Njamal people, despite both groups sharing a language, culture, and law. Throughout Njamal country, localised family groups had rights and responsibilities over certain portions of Njamal country that were passed down ancestrally. These traditional family areas are maintained today (Terra Rosa 2021).

There was an emphasis on 'looking after country', which incorporates looking after plants, animals, spiritual beings in country, places the old people have used, waterways and passing on country to the next generation (Terra Rosa 2021).

10.3.3.4 Flora and fauna

The Njamal spoke of caring for flora and fauna of the McPhee Creek area as part of their role and responsibility as a Traditional Owner and advised the Proponent that flora species of cultural significance (bush tucker and medicinal plants) should be recorded, protected and used in rehabilitation where possible (Terra Rosa 2021).

The Njamal also spoke of fauna species in the Development Envelope that have high cultural significance, for example the palkundji (Pilbara Olive Python) (Terra Rosa 2021).

The Njamal requested that the Proponent facilitate an ethnobotanical survey within the Development Envelope as a way of transferring cultural knowledge to younger Njamal people. Interest was also expressed in the production of study resources, such as booklets, posters or learning aids, on key cultural uses and the importance of flora and fauna, for the Njamal community.

10.3.3.5 Access to country

The provision of ongoing access to country was identified as a key consideration. The Njamal noted that they would like access to all areas of the Development Envelope after the life of mine and requested that the Proponent ensure all areas can be safely accessed, particularly heritage sites. The Njamal also recommended that the Proponent should consult with Njamal regarding the potential creation of additional access tracks to specific heritage sites, either during the life of the mine, or following mine closure as required for the provision of ongoing access (Terra Rosa 2021).

10.3.3.6 Water

The Njamal expressed that maintaining Yinta sites and their surrounds (including creeklines) is a central role and responsibility of a Njamal Traditional Owner (Terra Rosa 2021).

Throughout the Social Surroundings consultation and during prior heritage surveys, the Njamal have spoken of the significance of water sources, in particular permanent sources. Water and its management were identified as key considerations in relation to the social landscape, with the Njamal people expressing that they need to be involved in the monitoring and management of waterways in the Development Envelope (Terra Rosa 2021).

10.3.4 Natural and historic heritage

A desktop search of the State Register of Heritage Places (inherit database) identified 15 records within the vicinity of Nullagine townsite. None of these sites are located within the Development Envelope or within the location of creeks subject to wetting front from discharge of water. Furthermore, no sites listed on Australia's National Heritage List have been identified as being located within or adjacent to the Development Envelope.

10.4 Potential environmental impacts

10.4.1 Direct impacts

The potential direct impacts of the Proposal to social surroundings, including heritage sites, cultural values and environmental values within or surrounding the Development Envelope have been identified as follows:

- disturbance to sites of cultural and heritage significance
- restriction of access to country
- altered amenity as a result of changes to landforms or installation of infrastructure.

10.4.1.1 Disturbance to sites of cultural and heritage significance

The Development Envelope includes 83 heritage sites of value to the Njamal (Figure 10-1). These sites may or may not meet the criteria for an Aboriginal site under the AH Act. This decision can only be made by the Aboriginal Cultural Material Committee (ACMC), based on submission of detailed information and consultation records.

10.4.1.2 Restriction of access to country

Implementation of the Proposal including ground disturbance and placement of infrastructure has the potential to alter or restrict access of the Njamal to country, including sites of cultural or heritage significance. This has the potential to impact traditional social activities and practices, and connection to country.

10.4.1.3 Altered amenity as a result of changes to landforms or installation of infrastructure.

The construction and operation of the Proposal is predicted to alter the visual amenity of the local landscape as a result of the excavation of mine pits, construction of waste dumps and supporting infrastructure. This may alter the experience of the Njamal when on country, as well as residents and visitors of Bonney Downs Pastoral Station (which intersects the southern portion of the Development Envelope), and travellers utilising Marble Bar Road, located within 2 km from the eastern boundary of the Conceptual Footprint.

10.4.2 Indirect impacts

Potential indirect impacts of the Proposal to Social Surroundings, including heritage sites, cultural values and environmental values within or surrounding the Development Envelope have been identified as follows:

- Disturbance to sites of cultural significance as a result of altered hydrological regimes.
- Disturbance to sites of cultural significance as a result of dust and vibrations.
- Disturbance to broader cultural associates as a result of environmental changes to country.

10.4.2.1 Disturbance to sites of cultural significance as a result of altered hydrological regimes

Altered hydrological regimes from the installation of infrastructure, excavation of mine pits, groundwater drawdown and discharge of surplus water, have the potential to indirectly impact sites of cultural significance or areas of cultural significance.

10.4.2.2 Disturbance to sites of cultural significance as a result of dust and vibrations

Construction and operation of the Proposal has the potential to alter the amenity of the local area and surrounds, as a result of dust, noise and vibration emissions. These emissions also have the potential to result in impacts to heritage sites and/or cultural values.

During the social surroundings consultation (Terra Rosa 2021), it was stated several times that the significance of indirect impacts such as noise, vibration and dust varies markedly depending upon the type of heritage site affected. Indirect impacts at an artefact scatter or quarry site were generally considered to be of low significance, while such indirect impacts at an engraving site or walled niche were considered of higher significance.

Dust emissions from construction and operation, including blasting may result in dust deposition at sites of significance and has the potential to degrade the condition of these sites. This may be particularly relevant where engravings or grinding sites are in close proximity to active mining.

Active mining, in particular blasting, has the potential to impact the structural integrity of rock shelters as a result of vibrations. The Proposal is expected to result in noise emissions from the use of vehicles, machinery, and active mining. During operation, mining will occur on a 24-hour basis, seven days per week. This has the potential to alter the experience of the Njamal when on country, including when visiting heritage sites.

10.4.2.3 Disturbance to broader cultural associates as a result of environmental changes to country

The Njamal have advised the Proponent that flora species of cultural significance (bush tucker and medicinal plants) exist in the Development Envelope and should be recorded, protected and used in rehabilitation. The Proponent proposes to involve the Njamal in the collection of seed for use in rehabilitation (with further details to be provided in the final CHMP and final MCP; Appendix T and Appendix A).

Similarly, the Njamal spoke of fauna species that have high cultural significance, for example the palkundji or Pilbara Olive Python (Terra Rosa 2021). The palkundji are endemic to the Pilbara region, and have been recorded five times within the Development Envelope, with one further record from within the SFEZ. Two additional previous records are from outside of the Development Envelope (Biologic 2020b; Outback Ecology 2012b). A number of habitat types present in the Development Envelope likely provide high value breeding/shelter and hunting/foraging habitats for the species, including Gorge/Gully, Breakaway/Cliff, Drainage Line and Hillcrest/Hillslope habitat types. Furthermore, surface water pools in proximity to rocky habitats are considered high value foraging habitat as they support hunting. Little is known about the breeding of Pilbara Olive Python; however, it is understood that young disperse in search of food (DAWE 2020e), so it is considered likely that surface water pools in proximity to high value breeding habitat, are of the highest value. The surface water pools on the McPhee Range and within McPhee Creek to the south of the Development Envelope are considered to be of high value and the species has been recorded in these locations (Biologic 2021a). Other pools present in the Development Envelope and in the three creeklines south of the Development Envelope, namely McPhee Creek, a Branch of McPhee Creek and Lionel Creek, are also likely to support hunting.

10.4.3 Cumulative impacts

Native vegetation and fauna are important to Traditional Owners for cultural uses, i.e. bush tucker and bush medicines. As outlined in Section 7 (Flora and Vegetation) and Section 8 (Terrestrial Fauna) of this ERD with respect to broad values for native vegetation and terrestrial fauna habitat, the cumulative impact of the Proposal will be minor, and this is expected to be reflected in any cumulative impacts on culturally important flora and fauna values.

It is recognized that the Njamal Native Title Claim Area (WC 1999/008) is overlapped by pastoral leases. Historical pastoral activities may have degraded aspects of cultural heritage, but these effects are not well understood. Similarly, there are no publicly available records of registered heritage sites disturbed or destroyed under Section 18 of the AH Act, so it is difficult to assess the potential cumulative loss to the Njamal people in this regard. However, as the Njamal have been involved in heritage surveys throughout their determination and claim areas, for numerous projects, and are formally consulted by DPLH in relation to all applications to disturb sites under the AH Act, they are considered to have a holistic view of all values present and activities occurring across these areas. As such, their assessment of potential impacts to Social Surroundings values within the Development Envelope has taken into account the cumulative impacts from all activities occurring across their determination and claim areas.

10.5 Mitigation

During Proposal design, the mitigation hierarchy (avoid, minimise and rehabilitate) has been applied to avoid and minimise potential impacts of the Proposal to social surroundings as far as practicable.

The Development Envelope for the Proposal has been defined to exclude the SFEZ. While nominated primarily for the avoidance of significant environmental values, the SFEZ also sought to protect heritage values including a cave and artefact scatter site (Figure 10-1).

In addition, the Conceptual Footprint has undergone several iterations and ultimately been developed to avoid a number of the heritage sites within the Development Envelope. This process of rationalisation of the Conceptual Footprint, through the development of a more detailed design was undertaken to further reduce, as far as possible, the number of sites potentially directly impacted by the Proposal and involved:

- Review of the proposed disturbance areas associated with roads, camp, laydowns, topsoils stockpiles, and sediment basins, as the exact locations/layouts of such infrastructure can be flexible.
- Review of waste dump locations and layouts to identify options for the further avoidance of heritage sites.
- Review of pit locations and layouts to identify options for the further avoidance of heritage sites.

As a result of the above rationalisation process, the following changes were made in finalising the Conceptual Footprint to further avoid impacts to heritage sites (including artefact scatters, quarries, rock holes (pools), grinding stones, modified trees, and rock shelters):

- Amendment of Avon and Murray Pit footprints.
- Amendment of topsoil stockpile footprint.
- Amendment of borrow pit footprint and associated track.
- Realignment of access road to Crescent Moon deposit.
- Amendment of Avon, Murray, Ord and Nicholson waste dumps.

- Realignment of road adjacent to proposed new accommodation camp.

The final mine layout will be confirmed following additional discussions with the Njamal, including on-country consultation. Other mitigation actions to address the potential impacts and predicted outcomes for social surroundings are presented in Table 10-4.

Table 10-4: Application of the mitigation hierarchy for social surroundings

Impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Direct impact: disturbance to sites of cultural and heritage significance	• Conceptual Footprint amended to avoid key heritage sites with ongoing refinement of the Mine Plan to maximise site avoidance. • Salvage of heritage materials will be undertaken by the Njamal, supported by the Proponent, prior to direct impact. • Heritage sites will be demarcated and identified as no-go areas for site personnel.	• Disturbance will be managed through the Proponent's Ground Disturbance Permit (GDP) Procedure to avoid unauthorised disturbance to sites and places of cultural significance. • Appropriate education of the workforce will occur through a Cultural Awareness Training program involving Njamal representatives.		• Ongoing review/modification of the footprint is being undertaken with the aim to minimise disturbance to sites of cultural and heritage significance, as guided by ongoing consultation. • Impacts to specific sites of cultural and heritage significance, if unavoidable, will be discussed with Njamal and assessed under the AH Act.
Direct impact: restriction of access to country	• Heritage sites will be demarcated and identified as no-go areas for site personnel.	• The Proponent will continue to consult with the Bonney Downs leaseholder to ensure impacts of the Proposal on their activities/land use are minimised. • Where it is safe to do so, the Proponent will provide for ongoing access to the Development Envelope by the Njamal during construction and operations through: • Involvement of Njamal people in	•	• Post-closure access to sites of cultural significance will be maintained. • Impacts to access post-closure will be limited to areas immediately adjacent to pits (due to safety reasons).

Impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		flora, fauna and water monitoring. • Involvement of Njamal people in heritage site monitoring. • Potential creation of additional access tracks to specific heritage sites (if required).		
Direct impact: altered amenity as a result of changes to landforms or installation of infrastructure		• Waste dumps will be designed to blend in with the surrounding landscape.	• Upon closure, revegetation works will be implemented in accordance with the approved Mine Closure Plan (Appendix A).	• Impacts to amenity will decrease through the rehabilitation and closure phase. • With the exception of the pits, the vast majority of the footprint will be rehabilitated, such that significant long-term impacts to visual amenity do not occur.
Indirect impact: disturbance to sites of cultural significance as a result of altered hydrological regimes	• Avoidance of mine dewatering and surface water discharge is not possible for this Proposal.	• Total volume of dewatering cannot be minimised. However, the Proponent is investigating an early commencement of dewatering (subject to approval) to minimise peak dewatering rates. • Discharge rates will be managed between creeks to minimise	• Waste dumps at closure will be rehabilitated to ensure they are stable and revegetated. • Design of closure landforms to minimise long-term impacts to hydrological regimes associated with to sites of cultural significance	• Changes in hydrological regimes within water courses, and associated heritage sites, within the Main Range. Minor to negligible changes in hydrological regimes beyond the Main Range.

Impact	Avoidance	Minimisation	Rehabilitation	Residual impact
		impacts to pools and long-term mounding in alluvial aquifers. • Discharge locations will be constructed with scour and erosion protection. • Only water that is surplus to operational requirements will be discharged. • Surface water management during mining and closure will be designed to reduce where practicable adverse impacts on the natural function and environmental value of watercourses, water quality and sheet flow downstream of the mine area.		
Indirect impact: disturbance to sites of cultural significance as a result of dust and vibrations	• Avoidance buffers will be established around retained heritage sites, in consultation with the Njamal (Appendix T).	• The Proponent will implement standard dust management measures to minimise potential airborne dust emissions and associated impacts to amenity.	• Upon closure, revegetation works will be implemented in accordance with the approved Mine Closure Plan (Appendix A).	• Impacts to amenity due to dust will decrease through the rehabilitation and closure phase. • Following rehabilitation, no significant long-term impacts to amenity due to dust are expected.

Impact	Avoidance	Minimisation	Rehabilitation	Residual impact
Indirect impact: disturbance to broader cultural associations as a result of environmental changes to country		• Offsets are proposed for the removal of approximately 670.2 ha of high value habitat for palkundji (Pilbara Olive Python). These offsets are outlined in Section 13. It is noted that approximately 387.8 ha of high value breeding/shelter and hunting/foraging habitat for palkundii will remain available in the Development Envelope and an additional 115.1 ha of high value habitat and five surface water pools will be retained within the SFEZ.	• The Proponent will investigate the feasibility of creating alternative surface water sources for native fauna (to be detailed within the Mine Closure Plan). • Seed collection prior to/during construction and operations for use in rehabilitation (including Njamal representatives).	• The residual impacts to Country will be discussed with Njamal and avoided/minimised where possible.

10.6 Assessment and significance of residual impact

10.6.1 Direct impacts

10.6.1.1 Disturbance to sites of cultural and heritage significance

Alteration of the Conceptual Footprint has resulted in the avoidance of impacts to 16 of the known sites of value to the Njamal within the Development Envelope. However, it is recognised that there are a number of heritage sites which are potentially still directly impacted by the Proposal. The number of sites and extent of impact to each site will be further discussed with the Njamal during proposed on-country consultation in support of AH Act approvals, and subsequently at a MALC meeting.

Should future removal or destruction of Aboriginal sites be required, the Proponent commits to it being undertaken in consultation with the Njamal and in accordance with the requirements of the AH Act (including consideration for any future revisions of the Act).

10.6.1.2 Restriction of access to country

The Proponent commits to ongoing engagement with the Njamal in relation to ongoing access into the Development Envelope, which is a requirement under the Claim-wide agreement, noting that heritage sites in close proximity to active mining may become inaccessible for periods of time for safety reasons.

As outlined in the preliminary CHMP (Appendix T), the Proponent intends to provide for ongoing access during construction and operations through:

- Involvement of the Njamal people in flora, fauna and water monitoring.
- Involvement of the Njamal people in heritage site monitoring.
- Potential creation of additional access tracks to specific heritage sites, if required.

The Proponent also aims to provide for ongoing access post-closure to sites and places of cultural significance.

It is noted that implementation of the Proposal also has the potential to provide an opportunity for ready access by workforce personnel to sites of cultural sensitivity. The Proponent will restrict workforce access to heritage sites within the Development Envelope except for access for the purposes of monitoring, which will involve Njamal representatives.

The above proposed controls in relation to ongoing consultation with the Njamal, workforce access to areas of cultural concern, the provision of ongoing access by the Njamal to the Development Envelope, and the support of the Njamal 'back to country' trips in other areas of Njamal country, are expected to be sufficient to prevent a significant impact to social surroundings.

10.6.1.3 Altered amenity as a result of changes to landforms or installation of infrastructure

Visual impacts from the proposed infrastructure at adjacent heritage sites was discussed with the Njamal during the social surroundings consultation (Terra Rosa 2021). In particular, it was agreed that the design of the waste dump adjacent to engraving sites would be modified to pull back from the site boundaries, to reduce visual impacts. Furthermore, it was noted that while significant visual impacts are expected at many sites during the construction and operations phase, rehabilitation of disturbance in proximity to key heritage sites will minimise impacts post-closure.

10.6.2 Indirect impacts

10.6.2.1 Disturbance to sites of cultural significance as a result of altered hydrological regimes

Several surface water pools present within the Development Envelope may be impacted by the Proposal. The Proponent expects to be able to avoid direct impacts to three pools (WMPC-03, WMPC-22 and WMPC-29), while indirect impacts (i.e. a reduction) to the catchments may occur resulting in a modification of inflows and potential changes to the persistence of water in these pools.

It is noted that an additional five surface water pools, including one permanent pool, will be protected within the SFEZ. Twenty-one pools occur outside of the Development Envelope and SFEZ. The maximum catchment losses for these pools is 11% in the Branch of McPhee Creek permanent pool (VMPC-77) located closest to the Development Envelope.

The Proposal is not expected to significantly impact the creekline catchments. McPhee Creek, Branch of McPhee Creek and Sandy Creek may experience catchment reductions of around 10% as a result of mining infrastructure. Spinaway Creek may experience minimal catchment loss, and no loss is expected for Lionel Creek. Some catchment flows are expected to be reinstated at closure. Given the rainfall patterns of the Pilbara, where most rainfall is episodic with generally short periods of runoff and creek flow, a small reduction in catchment and peak flows is unlikely to change the hydrological regime to the extent that it affects any cultural heritage or social values.

Discharge of surplus water to surface water systems is a common practice at many operations in the Pilbara. Controlled discharge to the creeks nearby the Proposal will not be continuous and peak discharge will occur early in mine life. It is likely that the maximum wetting fronts on each creek would only be reached for a short time (one to three years), if at all. Discharges are not expected to have a significant impact to the environmental values along these creeks due to the short term nature of peak discharges and the adaptation of these creeks to highly variable flows. Following cessation of dewatering, the hydrological regimes will return to pre-mining conditions with long dry periods and slightly reduced peak flows due to catchment reduction. Further discussion of hydrological regimes is described in Section 6.

A reduction in surface water flows immediately down catchment of the proposed pits has the potential to impact cultural and environmental values associated with rock holes. Potential impacts at each site will be further discussed with the Njamal during proposed further on-country consultation, and subsequently at a MALC meeting. Potential impacts to other environmental values associated with these surface water pools are addressed in Section 8 and Section 12.

Based on the above it is considered that dewater discharge flows and water quality can be managed to ensure no significant impact to heritage sites or areas of cultural significance to the Njamal. Further, mine closure planning will seek to minimise impacts to flora and fauna of cultural significance to the Njamal, such that no significant residual impacts remain following the life of mine.

10.6.2.2 Disturbance to sites of cultural significance as a result of dust and vibrations

The Proponent commits to implementing standard dust management measures to minimise airborne dust emissions and deposition outside of active mining areas. This is expected to minimise potential dust impacts on vegetation, visible airborne dust observed by Traditional Owners and/or nearby road and land users.

The draft CHMP (Appendix T) will be updated as additional on-country consultation provides additional information in relation to the identification and management of impacts, including those related to dust emissions, at engraving or Ngurrara sites.

Two rock shelters, currently intersecting the Conceptual Footprint and with the potential to host an archaeological deposit, were recommended for excavation to confirm the nature and extent of Aboriginal occupation of the rock shelters. The excavation of one of the rock shelters occurred in March 2022, in partnership with the Njamal. Following a detailed inspection of the second rock shelter by Njamal, excavation was deemed not to be of value. Potential direct or indirect impacts to each site will be further discussed with the Njamal, prior to any applications to disturb the sites under the AH Act.

A third rock shelter is located within the Development Envelope, on the boundary of the SFEZ, and is well removed (> 750 m) from the proposed Avon pit. Therefore, neither direct impacts, nor indirect impacts from blasting vibration, are expected.

Modelling of operational noise emissions has shown that outside of areas directly adjacent to active mining, noise levels generally fall below 60 dB L_{A10} which corresponds to the assigned noise level for noise sensitive premises (Lloyd George Acoustics 2021). Thus, amenity at the majority of locations within the Development Envelope, including heritage sites, is not expected to be significantly impacted by operational noise emissions. For safety reasons it is expected that during the construction phase, access to personnel other than the Proponent, including the Njamal, will be restricted in proximity (approximately 1 km) to work areas. Thus, impacts from noise and vibration at accessible sites are not expected to be significant.

The draft CHMP (Appendix T) will be updated as additional on-country consultation provide additional information in relation to the identification and management of impacts, including those related to noise and vibration, at Ngurrara sites.

10.6.2.3 Disturbance to broader cultural associates as a result of environmental changes to country

The Njamal spoke of the importance of ensuring animals have fresh water. Given the predicted acidity of pit lakes associated with the Proposal (refer Section 6), the Njamal suggested that, post-closure, alternative water sources be provided adjacent to pit areas (Terra Rosa 2021). The Proponent will investigate the feasibility of creating alternative surface water features (e.g. dams) adjacent to pits suitable for fauna use, in consultation with the Njamal. This will be further detailed within the detailed Mine Closure Plan (Appendix A).

Several surface water pools present within the Development Envelope may be impacted by the Proposal. The Proponent expects to be able to avoid direct impacts to three pools (WMPC-03, WMPC-22 and WMPC-29) which occur within the boundary of heritage site MCP-04-12, while indirect impacts (i.e. a reduction) to the catchments may occur resulting in a modification of inflows and potential changes to the persistence of water in these pools.

It is noted that an additional five surface water pools, including one permanent pool, will be protected within the SFEZ. Twenty-one pools occur outside of the Development Envelope and SFEZ. The maximum catchment losses for these pools is 11% in the Branch of McPhee Creek permanent pool (VMPC-77) located closest to the Development Envelope.

10.6.3 Cumulative impacts

The Proposal adds to existing impacts to social surroundings, including heritage values, in the Pilbara region of Western Australia.

The Proponent's operations in the region have retained prominent landscape features and avoided impacts to sites and places of cultural heritage value, as far as practicable. The Proponent has a proven track record of engaging with the Njamal to ensure the appropriate management of cultural heritage values.

The Proposal has been designed to avoid impacts to social surroundings as far as practicable. As outlined in Section 7 (Flora and Vegetation) and Section 8 (Terrestrial Fauna) of this ERD with respect to broad values for native vegetation and terrestrial fauna habitat, the cumulative impact of the Proposal will be minor, and this is expected to be reflected in any cumulative impacts on culturally important flora and fauna values.

10.7 Environmental outcomes

The predicted environmental outcomes for social surroundings from the Proposal after applying the mitigation hierarchy (avoid, minimise, rehabilitate) are:

- Impacts to several surface water pools, including three permanent pools, four semi-permanent pools and eight temporary/seasonal pools. Noting that the Proponent expects to be able to avoid direct impacts to three pools (WMPC-03, WMPC-22 and WMPC-29), however indirect impacts (i.e. a reduction) to the catchments may occur resulting in a modification of inflows and potential changes to the persistence of water in these pools.
- Impacts to a number of sites of heritage value to the Njamal within the Development Envelope. The exact number of sites and extent of impacts will be further discussed with the Njamal during proposed on-country consultation in support of AH Act approvals, and at a MALC meeting.
- Removal of approximately 670.2 ha of high value habitat for palkundiji (Pilbara Olive Python). This species has been identified as it is recognised as important to the Njamal. It is addressed further in Section 12.11.

10.8 Conclusion

The Proponent acknowledges the cultural values present within the Development Envelope to the Njamal Traditional Owners and consultation will be ongoing to manage impacts to these values. After the application of the mitigation hierarchy (Table 10-4; including preparation of a CHMP), and with ongoing consultation with Traditional Owners regarding the Proposal through both formal and informal forums, as well as obligations under the AH Act, the Proponent considers that the Proposal can be managed to meet the EPA's objective to *protect social surroundings from significant harm.*

11 Greenhouse Gas Emissions

11.1 EPA environmental factor objective

The EPA's objective for Greenhouse Gas (GHG) Emissions factor is to reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change (EPA 2021c).

11.2 Relevant policy and guidance

The relevant policy and guidance for Greenhouse Gas Emissions are described in Table 11-1.

Table 11-1: Relevant Policy and Guidance for Greenhouse Gas Emissions

EPA and other State or Commonwealth policy or guidance (if relevant)	Explain how the policy and guidance has been considered
Environmental Protection Authority	
Instructions on how to prepare an Environmental Review Document (EPA 2021d)	Considered during the development of this document
Statement of Environmental Principles, Factors and Objectives (EPA 2021c)	
Environmental Factor Guideline: Greenhouse Gas Emissions (EPA 2020b)	Considered in the design (methods and approach) of the greenhouse gas surveys or previous guidance (if survey undertaken before current guidelines)
Environmental Factor Guideline: Air Quality (EPA 2020a)	
Other State or Commonwealth	
National Greenhouse and Energy Reporting Act 2007 (NGER Act) (DISER 2007)	Considered in the impact assessment and offset strategy for terrestrial fauna
National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (DISER 2021)	

11.3 Scope of assessment

This assessment considers Scope 1 (direct) and, where relevant, Scope 2 (indirect) emissions associated with the Proposal over its lifetime. Scope 3 emissions have not been assessed as they are under the control of entities outside of the Proponent and are therefore optional to report and not included in the NGER scheme. Scope 1, 2 and 3 emissions are further discussed in Section 11.5.1.

11.4 Receiving environment

11.4.1 Studies and survey effort

Table 11-2 summarises the Proposal specific studies undertaken for Greenhouse Gas Emissions environmental factor.

Table 11-2: Summary of studies

Survey	Assessment type	Summary of survey effort
McPhee Creek Iron Ore Mine Greenhouse Gas Assessment (SLR 2021; Appendix U)	Desktop assessment	A GHG assessment assessing the predicted Scope 1 and Scope 2 emissions over the lifetime of the Proposal.
McPhee Preliminary power Analysis (Calibre 2021)	Desktop	An analysis of the McPhee Creek power needs over the lifetime of the proposal and an assessment of the alternative sources.

The Australian Government developed the Regional Natural Resource Management Planning for Climate Change Fund. Australia has 54 natural resource management (NRM) regions, which are defined by catchments and bioregions. These NRM regions are grouped into 'clusters', which largely correspond to the broad-scale climate and biophysical regions of Australia (Figure 11-1) (Watterson, I. et al., 2015).

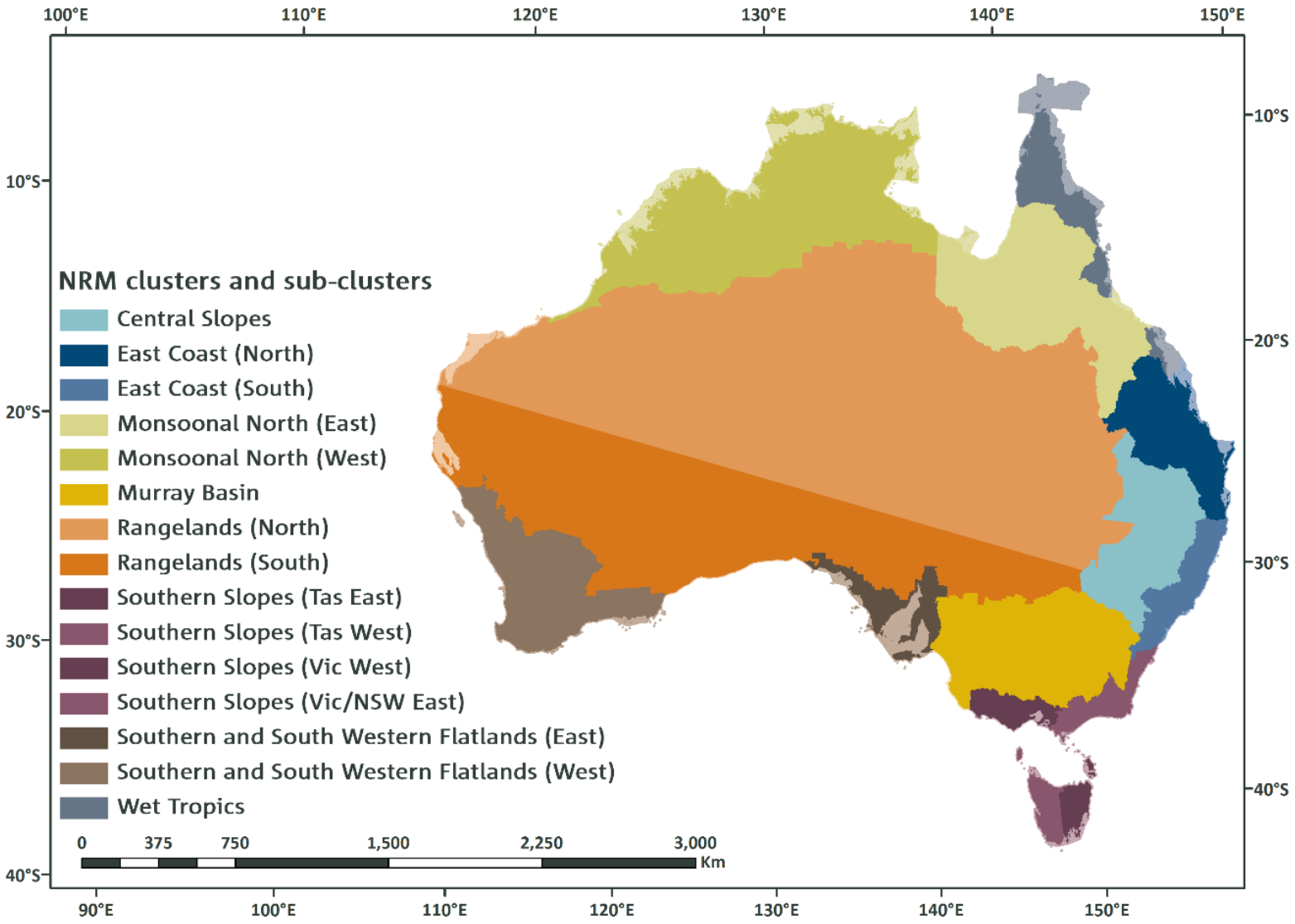

Figure 11-1: NRM clusters and sub-clusters

The McPhee Creek Development Envelope is in the Rangeland cluster (Rangelands North sub-cluster). The Rangelands cluster contains varied landscapes, including the Flinders and Pilbara Ranges, salt lakes that flood sporadically, and the centre of Australia. There is a wide range of vegetation, from tropical woodlands to shrublands, grasslands and saltbush, and it includes relatively intact ecosystems. The water features in the cluster are mostly intermittent, and aside from the coastal rivers of the west, most streams drain into salty lakes, in particular Lake Eyre. The cluster is home to many of Australia's indigenous people, and important agricultural activity includes the grazing of cattle and sheep. Rainfall systems vary from seasonally reliable monsoonal influences in the far north of the sub-cluster through to very low and variable rainfall patterns in much of the centre (Watterson, et al., 2015).

11.4.2 Western Australia's emissions

GHG emissions are a key contributor to climate change, with the effects of a changing climate predicted to be significant in Western Australia (EPA 2020b).

Gases other than CO_2 that contribute to the greenhouse effect are assigned a 'CO_2-equivalence' (CO_2-e) value for comparative purposes. The Global Warming Potential (GWP) index is utilised to calculate these values. The *Australian National Greenhouse Accounts Factors* workbook outlined the following 100-year GWPs of GHGs that have been used to calculate estimated emissions for the Proposal:

- CO_2 = 1
- CH_4 = 28
- N_2O = 265
- SF_6 = 23,500.

GHG emissions are classified as the following (EPA 2020b):

- Scope 1: emissions generated as a direct result of an activity e.g. diesel combustion by vehicles or gas consumption for on-site power generation.
- Scope 2: emissions generated from the consumption of an energy commodity.
- Scope 3: indirect emissions, other than Scope 2 emissions, that are generated in the wider community and occur as a consequence of the activities of a facility, but from sources not owned or controlled by that facility's business.

The EPA's GHG Emission guideline indicates that emissions from a Proposal will generally be assessed where Scope 1 emissions exceed 100,000 tonnes CO_2-e (t CO_2-e) (EPA 2020b).

The Proponent has well established procedures for the reporting of GHG emissions at its Pilbara operations in accordance with the NGER Act and is committed to an ongoing program of reporting and review to identify opportunities to further reduce energy consumption and reduce GHG emissions.

11.4.3 National and international requirements

Australia has two GHG emission targets under international agreements to reduce emissions (SLR 2021). Australia's target under the Kyoto Protocol was to have emission levels reduced to pre-2000 emissions levels by 2020, and this target appears to have been reached. In 2016, the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement committed Australia to reaching a reduction in GHG emissions by 26 – 28% below 2005 levels by the year 2030. As a Party to the United Nations Framework UNFCCC, the Kyoto Protocol and the Paris Agreement, Australia has made commitments to:

- reduce its greenhouse gas emissions
- track progress towards those commitments
- report each year on Australia's greenhouse gas emissions

11.5 Potential environmental impacts

The Proposal will produce GHG emissions as a result of diesel combustion, haulage and mining activities. The major GHG produced by the Proposal will be carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O). The Proposal has the potential to result in the generation of GHG emissions through:

- electricity generation.
- diesel combustion by fixed and mobile equipment.
- release of stored carbon in vegetation.

The increase in greenhouse gas emissions from the Proposals have a potential impact by contributing to global GHG concentrations.

The Australian Government predicts that future climate change projections for the Rangelands North sub-catchment predict (CSIRO, 2016):

- Average temperatures will continue to increase in all seasons with very high confidence
- More hot days and warm spells are projected with very high confidence
- Fewer frosts are projected with high confidence
- Changes to rainfall are possible but unclear
- Increased intensity of extreme rainfall events is projected, with high confidence; and
- Mean sea level will continue to rise, and height of extreme sea-level events will also increase with very high confidence.

Similarly, the Pilbara Conservation Strategy (Government of Western Australia, 2017a) notes that projected changes in rainfall, temperature and frequency of extreme weather events associated with climate change will affect the Pilbara region, in particular the magnitude or duration of extreme events.

11.5.1 Generation of GHG emissions

A detailed GHG assessment (SLR 2021) has been completed on behalf of the Proponent to understand and determine the likely Scope 1 emissions associated with the Proposal over its expected mine life of 15 years, plus one year of construction. It is assumed that the Proposal operations will occur 24 hours a day, 7 days a week for 50 weeks annually, with total operational days equal to 350 days per year. Calculations from this GHG assessment have been utilised to inform this ERD chapter.

11.5.1.1 Emission sources

The following sources of emissions were considered for assessment:

- Construction/Operation
    - Diesel combustion (Scope 1)
    - Combustion of petroleum-based greases and oils (Scope 1)
    - Drilling and blasting (Scope 1)
    - Excavation (Scope 1)
    - Production (crushing and screening) (Scope 1)
    - Clearing vegetation (Scope 1)

- Onsite wastewater generation (Scope 1)

- Energy production
  - Energy production using diesel generators (Scope 1).

- Transportation
  - Diesel combustion in third party trucks and other transportation equipment (Scope 3)
  - Downstream transport and processing of the ore into steel (Scope 3).

Since the Proposal's location is isolated from a power perspective, the option of obtaining electricity from the grid would not be considered as a practical power supply scenario. There are therefore no Scope 2 emission sources. Onsite power generated will be through diesel or alternate (solar) power sources where possible.

The Proposal involves the transportation of ore via road from the Development Envelope to the existing Roy Hill operation (116 km away) or other third parties. As per the NGER Act, the GHG emissions that arise from transportation have been considered as Scope 3 emissions as "they occur as consequence of the activities of the facility, but from sources not owned or controlled by that facility's business" (CER, 2021).

11.5.1.2 Scope 1 emission estimates

The GHG assessment identified three categories of emissions and determined that the Proposal is expected to contribute approximately 56,711t t CO_2-e of Scope 1 emissions annually (Table 11-3 and Figure 11-2).

Table 11-3: Calculated Scope 1 emissions (t CO_2-e) (SLR 2021)

Year	Diesel Combustion	Energy production emissions	Vegetation clearing emissions	Wastewater emissions	Total annual emissions
2023	42,179.2	2,086	30,847	85	75,197
2024	84,710.4	2,086	4,114	85	90,995
2025	79,821.7	2,086	4,114	85	86,107
2026	73,608.3	2,086	4,114	85	79,893
2027	76,998.6	2,086	4,114	85	83,284
2028	73,524.5	2,086	4,114	85	79,809
2029	43,111.4	2,086	4,114	85	49,396
2030	54,235.3	2,086	4,114	85	60,520
2031	46,458.1	2,086	4,114	85	52,743
2032	35,550.3	2,086	4,114	85	41,835
2033	34,244.0	2,086	4,114	85	40,529
2034	36,993.1	2,086	4,114	85	43,278
2035	35,260.2	2,086	4,114	85	41,545
2036	42,503.8	2,086	4,114	85	48,789
2037	14,648.0	2,086	4,114	85	20,933
2038	6,239.1	2,086	4,114	85	12,524
Total	**780,086**	**33,376**	**92,557**	**1,360**	**907,377**
Average annual emissions	**48,755**	**2,086**	**5,785**	**85**	**56,711**

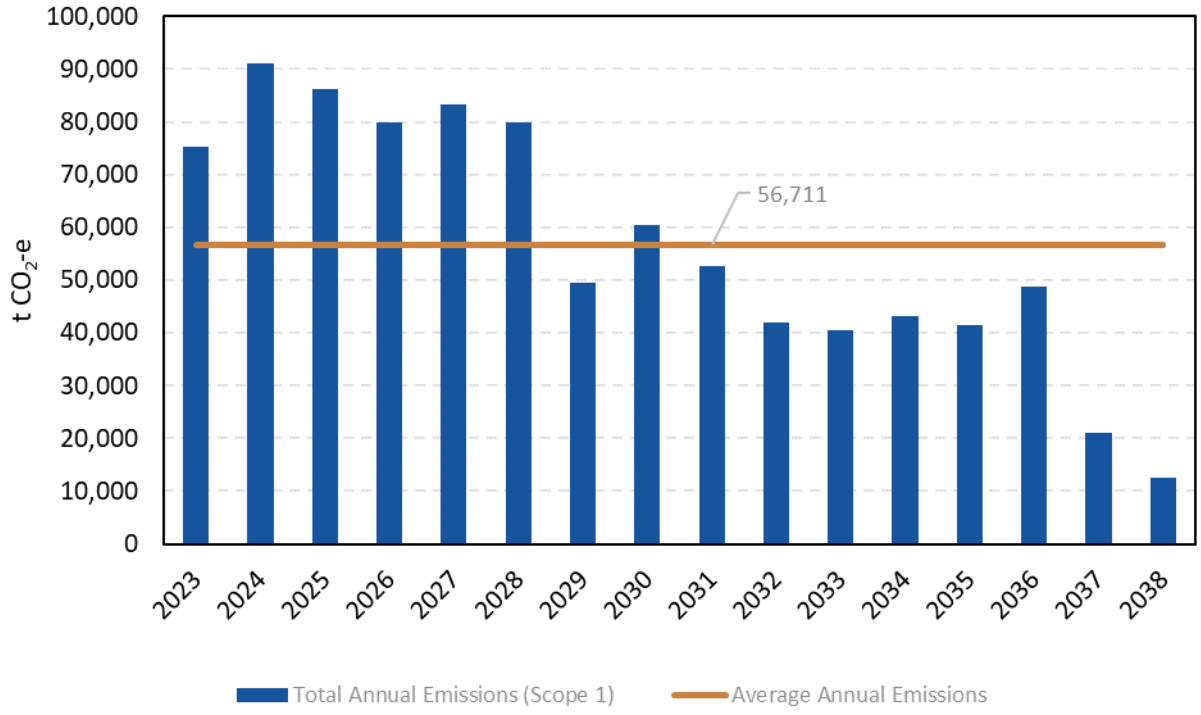

Figure 11-2: Calculated Scope 1 emissions for the Proposal

In 2019, Western Australia contributed to 17% of national emissions, with an emissions total of 91.8 $MtCO_2$-e. Australia's total emissions for 2019 was 529.3 $MtCO_2$-e. The Proposal's contribution to State and National emissions are outlined in Table 11-4.

Table 11-4: Proposal's contribution to State and National total annual emissions (SLR 2021)

	Proposal emissions
Proposal Annual Average Emissions (t CO_2-e/annum)	56,711 t CO_2-e
Emissions as a Percentage of National Inventory [a]	0.011%
Emissions as a Percentage of State Inventory [b]	0.062%
[a] National total emissions for 2019 = 529,297,700 [b] State total emissions for 2019 = 91,851,580	

11.5.1.3 Scope 3 emissions estimates

The most significant contributors to Scope 3 emissions result from:

- the transport of ore (ROM product), by a third party contractor, from McPhee Mine to Roy Hill or other processing location
- the processing of the ROM product at Roy Hill mine or other third parties, transport to and loading at Port
- the downstream transport (shipping) of ore
- processing of the ore into steel.

Other Scope 3 emissions include the upstream and downstream emissions associated with the materials produced by the Proposal (SLR 2021). This includes the upstream indirect emissions related to purchased materials and services; and the downstream indirect emissions associated with sold materials and services. These Scope 3 emissions are under the control of entities outside

of the Proponent and are therefore difficult to predict, optional to report and not included in the NGER scheme.

Scope 3 emissions from the projected life of mine are estimated to be as follows:

- Transport of ore to Roy Hill: 26ML/per annum of diesel is expected to be required for quad road train haulage. This equates to approximately 70,450 t CO_2-e per annum.
- Processing of ROM product, transport to Port and loading to ships: Utilising existing Roy Hill data, 196,000t CO_2-e per annum is expected (based on a carbon intensity of 0.014 t CO_2-e per tonne of iron ore). Emissions from processing of ore at Roy Hill have been assessed as Scope 1 emissions under the Roy Hill Revised Proposal (EPA Assessment no. 2214).
- Shipping is approximately 1.12Mt CO_2-e per annum (based on 0.08t CO_2-e per tonne of iron ore).
- Steelmaking is approximately 12.32Mt to 18.9Mt CO_2-e per annum (based on 0.88-1.35 t CO_2e per tonne of iron ore).

The emissions estimate assumes the integrated steelmaking route, based on the blast furnace and basic oxygen furnace, which uses raw materials including iron ore, coal, limestone and recycled steel. On average, this route uses 1,370kg or iron ore, 785kg of metallurgical coal, 270kg if limestone, and 125kg of recycled steel to produce 1,000kg of crude steel.

The shipping and steelmaking emissions estimates are consistent with that assumed for Roy Hill mine, as the McPhee ore will be processed with Roy Hill product. Should the McPhee ore be transported to other third parties, it is assumed the scope 3 emissions for shipping or steelmaking would not differ greatly.

11.5.1.4 Carbon intensity

The carbon intensity of a project refers to the total amount of carbon by weight that is emitted per unit of saleable product/service that is produced (SLR 2021). The McPhee Creek GHG Assessment emissions intensity calculation was based on an average production rate of 10 Mtpa of ore (SRL 2021). However the Proposal is seeking approval for up to 14 Mtpa. The Proposal will still aim to meet the emissions intensity regardless of the production rate. With approximate average annual emissions of 56,711 t CO_2-e, the Proposal has an anticipated emissions intensity of 0.0057 t CO_2-e per tonne of ore produced over the lifetime of the mine (Table 11-5).

Table 11-5: Annual carbon intensity over the life of the Proposal (SLR 2021)

Year	Proposal emissions (t CO_2-e)	Carbon intensity (t CO_2 / t ROM)
2023	75,197	0.0075
2024	90,995	0.0091
2025	86,107	0.0086
2026	79,893	0.0080
2027	83,284	0.0083
2028	79,809	0.0080
2029	49,396	0.0049
2030	60,520	0.0061
2031	52,743	0.0053
2032	41,835	0.0042
2033	40,529	0.0041

Year	Proposal emissions (t CO_2-e)	Carbon intensity (t CO_2 / t ROM)
2034	43,278	0.0043
2035	41,545	0.0042
2036	48,789	0.0049
2037	20,933	0.0021
2038	12,524	0.0013
Average	**56,711**	**0.0057**
Total	**907,377**	

11.5.2 Generation of greenhouse gas emissions through electricity generation.

The estimated greenhouse gas emissions associated with energy production are Scope 1 emissions resulting from diesel generators. The estimated greenhouse gas emissions produced over the life of the Proposal due to energy production is 33,376 t CO_2-e (Table 11-3).

11.5.3 Generation of greenhouse gas emissions through diesel combustion by fixed and mobile equipment.

The Proposal will operate 24 hours a day and include activities standard to iron ore mining for the Pilbara region including drilling, blasting and excavation of ore and haulage of waste and ore from the pits to the waste dumps and Run of Mine (ROM) respectively.

The majority of operational GHG emissions will derive from heavy mining equipment and ancillary mine support vehicles. The GHG emissions associated with the diesel combustion by fixed and mobile equipment over the life of the mine (including construction and closure) is estimated to be 780,084 t CO_2-e (Table 11-3).

11.5.4 Generation of greenhouse gas emissions through loss of carbon through clearing of vegetation and wastewater

The Proposal seeks to clear of up to 1,913 of vegetation. Clearing of vegetation results in the release of stored carbon within that vegetation and contributes to loss in capacity to sequester carbon. A major portion of the clearing is forecast to occur in the first year reaching approximately 33% of the total area to be cleared. The remaining area will be cleared over the subsequent fifteen years of the project as required for the development of new landforms and infrastructure.

An accommodation facility and offices will also cater for up to 220 personnel of which wastewater treatment plants will be utilised.

Clearing of vegetation and treatment of wastewater has potential to generate GHG emissions as provided in Table 11-3.

11.6 Mitigation

Due to the nature of mining, complete avoidance of GHG emissions is not possible. The mitigation hierarchy for the Greenhouse Gas Emissions factor involves the following three steps:

- Avoid emissions through best practice design.
- Reduce emissions over the life of a project.

- Offset emissions (carbon offsets) as per the GHGMP (Appendix V), through the implementation of a GHG offsets package (EPA 2020b).

During the design of the Proposal, this mitigation hierarchy has been applied to reduce the potential GHG emissions of the Proposal. A summary of the mitigation measures applied to address the key potential impacts of GHG emissions is provided in Table 11-6.

Table 11-6: Application of mitigation hierarchy for greenhouse gas emissions

Potential impact	Avoid	Reduce
Direct impact: generation of greenhouse gas emission through electricity generation	• Removal of site-based processing. Avoids need for additional electricity usage.	• Limit clearing to 1,913 ha within the Development Envelope • Options have been assessed and the most appropriate option chosen to avoid GHG emissions. This is described in detail in the Greenhouse Gas Management Plan (Appendix V) • Investigated option of utilising solar energy, however no great difference found.
Direct emissions from combustion of diesel, petroleum-based greases and oils combustion in all onsite mobile equipment	• Optimisation of haul routes and truck operation • Increase operation efficiency through mine planning, design and scheduling	• Use of diesel fuel additive • Optimise design of mine to reduce pump/conveyor distances and corresponding electricity usage. • Selection of energy efficient mobile equipment • Optimise blasting techniques to improve dig rates which subsequently increases digger utilisation and reduces truck idle times, resulting in reduced fuel use • Reducing emissions in accordance with the interim targets set in the Greenhouse Gas Management Plan (Appendix V) • Limit double handling to reduce the total material transported • Use buses/carpooling to transport personnel between airport and site • Locate accommodation in close proximity to Mine Operations Facility to reduce travel • Regular inspection, maintenance and replacement of equipment so that energy efficiency is maximised during the life of the item • Design and construction of accommodation camp and support facilities to sustainable standards • Use of solar photo-voltaic panel powered lighting and pumps where possible • Implement energy management, optimisation and efficiency plans and initiatives

Potential impact	Avoid	Reduce
		• Comply with the National Greenhouse and Energy Reporting • Undertake a 5-yearly assessment of reasonable and practicable emission reduction equipment and technologies • Investigate feasibility of mining fleet electrification
Direct impact: generation of greenhouse gas emissions through clearing of vegetation	• Manage vegetation clearing in accordance with the Ground Disturbance Procedure.	• Limit clearing to 1,913 ha within the Development Envelope.

11.7 Assessment of significance of residual impact

The estimated direct annual average GHG emissions for the Proposal is 56,711 t CO_2-e. The total emissions over the life of the Proposal is estimated to be 907,377 t CO_2-e. In comparison with similar West Australian mining projects, the emissions intensity (t CO_2-e produced per tonne of ore) of the Proposal is below the average, with an emissions intensity of 0.0057 t CO_2 / t ore (Table 11-8).

These estimated GHG emissions indicate that the Proposal's contribution to State and National emissions is minimal, accounting for less than 0.1% of total annual State emissions and less than 0.02% of total annual national emissions (Table 11-4).

The Proponent is committed to implementing a Greenhouse Gas Management Plan (GHGMP; Appendix V) to minimise GHG emissions as much as practicable, over the life of the project and to ensure that emissions are aligned with Australia's agreed GHG reduction targets. The GHGMP further describes the sources of emissions and describes how the mitigation hierarchy has been applied to the Proposal.

11.7.1 Generation of greenhouse gas emissions through electricity generation

The estimated greenhouse gas emissions produced over the life of the Proposal due to electricity generation is 33,376 t CO_2-e (Table 11-3), approximately 4% of the total emissions of the Proposal (SLR 2021). This accounts for 0.002% of total annual State emissions and 0.0003% of total annual National emissions. It is noted that the Proponent has previously investigated using some solar energy for this Proposal however this was decided against as it provided marginal benefit in terms of GHG emissions.

11.7.2 Generation of greenhouse gas emissions through diesel combustion by fixed and mobile equipment

The GHG emissions produced from diesel combustion by fixed (stationary) and mobile (transportation) equipment are the largest contributors to the total emissions of the Proposal. Diesel combustion by fixed equipment contributes to an average of 67% of total annual emissions. This accounts for 0.07% of total annual State emissions and 0.01% of total annual national emissions. Diesel combustion by mobile equipment contributes to an average of 29% of total annual emissions. This accounts for 0.03% of total annual State emissions and 0.005% of total annual National emissions.

The proponent is committing to manage GHG emissions through 5 yearly step reductions to ensure consistency with the net zero emissions by 2050 trajectory (Figure 11-3 and Table 11-7). The zero net emissions trajectory for the Proposal initiated in Financial Year (FY) 2024 as this is the first full year of mining. To meet these targets emission reduction initiatives will be implemented to either avoid, reduce, or offset emissions as outlined in the GHGMP (Appendix V).

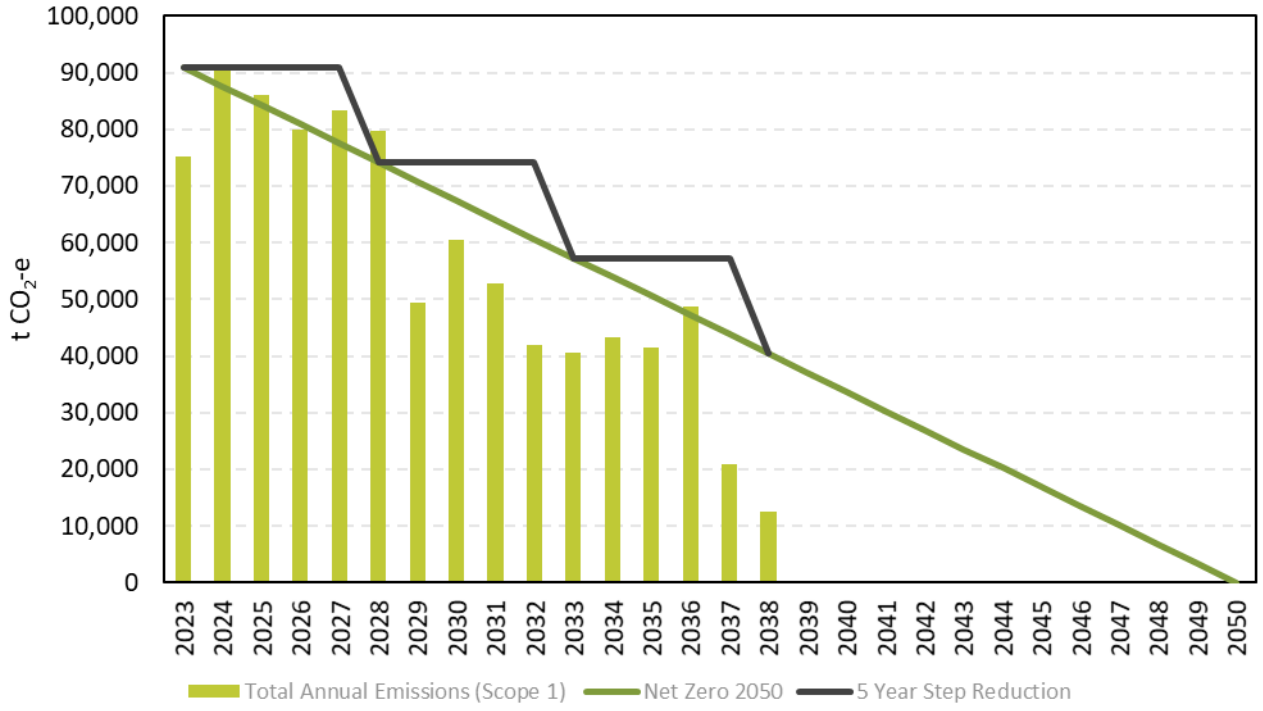

Figure 11-3 Interim Emissions Targets – Scope 1 emissions

In the event that the Proponent is not able to meet the proposed targets, the Proponent will offset the excess emissions by purchasing carbon credits (local or international) that meet offset integrity principles and are based on clear, enforceable and accountable methods.

Table 11-7 Interim Emissions Targets – Scope 1 emissions

Year	FY 2023	FY 2028	FY 2032	FY 2036
Annual Emissions Targets (tCO_2-e)	90,995	74,144	57,293	40,442

11.7.3 Generation of greenhouse gas emissions through vegetation clearing and wastewater

Progressive vegetation clearing over the life of mine is expected to result in GHG emissions of 5,785 tCO_2-e per year and 92,557 tCO_2-e over the life of the project (Table 11-3).

Emissions associated with the disposal of wastewater at the Proposal are estimated to be 85 tCO_2-e per year and 1,360 tCO_2-e over the life of the project (Table 11-3).

11.7.4 GHG benchmarking

The benchmarking assessment of the GHG emissions was undertaken to compare the carbon intensity of the Proposal against other comparable West Australian mining projects (SLR 2021) (Table 11-8).

Table 11-8: Benchmarking against comparable mines in the Pilbara (SLR 2021)

Project	Ore production (tonnes per annum)	Total average Scope 1 emissions (tCO_2-e per annum)	Emissions intensity (tCO_2-e/t ore)
Roy Hill Iron Ore Mine	59,100,000	466,000	0.0079
BHP Mining Area C	150,000,000	1,200,000	0.0080
BHP Jimblebar	50,673,195	414,000	0.0082
FMG Solomon	39,650,000	324,651	0.0082
Rio Tinto West Angelas	35,000,000	315,825	0.0090
West Australian Iron Ore Industry	-	-	0.0098
Rio Tinto Pilbara	325,000,000	3,200,000	0.010
McPhee Creek Iron Ore	**10,000,000**	56,711	0.0057

Comparison of emissions from individual mining operation is challenging, as site-specific circumstances which influence GHG intensity are different from site to site, such as waste to ore ratios, grade characteristics, topography and scale of Below Water Table (BWT) mining. For instance, ore deposits characterised by a low strop ratio and Above Water Table (AWT) mining would expect to result in lower GHG intensity as waste movements are reduced and ore processing simplified. Boundary conditions (defining limits on assessment calculations) may also change between site, for example some aspects of mining, processing and transport may be contracted to a third party that assumes operational control and hence ownership of a portion of a facility's GHG emissions. Benchmarking has been undertaken for comparison of estimated Scope 1 emissions intensity against comparable operations to the Proposal. The Proponent has chosen projects that have similar emissions sources (including emissions from mining and clearing, and excluding emissions from ore transportation) for a more accurate representation.

11.8 Environmental outcomes

The outcomes of the assessment of potential impacts and proposed mitigation measures to avoid, reduce and offset the GHG emissions of the Proposal meet the EPA's objective for this factor. The predicted environmental outcomes for GHG emissions are as follows:

- Annual average GHG emissions (Scope 1) over the life of the Proposal are estimated to be 56,711 t CO_2-e
- The Proposal/s carbon intensity is estimated to be 0.0057 t CO_2-e per tonne of ore produced
- The Proposal's contribution to State and National emissions is minimal, accounting for less than 0.1% of total State emissions and less than 0.02% of total national emissions
- The carbon intensity of the Proposal reduces over the life of the mine, despite the production rates remaining at 10,000,000 tonnes per annum, as GHG emissions reduce due to lower diesel combustion as mine development progresses.

While the Proposal will result in GHG emissions, comparison to similar mining projects in Western Australia indicate that the Proposal's average annual Scope 1 emissions and emissions intensity are lower than other projects. This is due to the design decisions and mitigation measures established for emission management, which will be implemented through the GHGMP (Appendix V). Furthermore,

the estimated annual average emissions of the Proposal are below 100,000 t CO_2-e, which is the level over which the EPA generally assesses a proposal (EPA 2020b).

After application of the mitigation hierarchy and implementation of the GHGMP (Appendix V), no significant residual impacts have been identified.

11.9 Conclusion

Given the mitigation measures to be applied and the development and application of a GHG Management Plan (Appendix V), the Proponent considers the Proposal can be managed to meet the EPA's objective *to reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change*.