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Mt Keith Satellite Project Environmental Review – Volume 1

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Executive Summary

Introduction

BHP Billiton Nickel West (**NiW**) proposes to develop the Mt Keith Satellite Project (MKS **Proposal**), approximately 80 km north of Leinster in the Shire of Leonora and 20 km south of the Mt Keith Mine (Figure ES1). The proposal is located within granted mining leases held by either BHP Billiton Nickel West Pty Ltd (**Proponent**) or its wholly owned subsidiary BHP Billiton Yakabindie Nickel Pty Ltd; and the Yakabindie Pastoral Lease, which is held by NiW. Portions of this Pastoral Lease are sublet to a third party for the conduct of pastoral activities.

The existing Mt Keith Nickel Operation (**NMK**) is an open pit nickel mine, wholly owned and operated by NiW, a subsidiary of BHP. NMK comprises an open cut mine, waste rock landforms, nickel sulphide concentrator, tailings storage facility and supporting infrastructure. Mining is undertaken at a rate of 30 to 50 million tonnes per annum (**Mtpa**). Nickel concentrate is transported via road to Leinster for drying and blending. The final blend is transported from Leinster to Kalgoorlie Nickel Smelter via road and rail, for further processing.

Background and Context

In 1990, the Environmental Protection Authority (**EPA**) assessed a proposal to mine nickel and process low-grade nickel sulphide in a similar location to the current Proposal within the Yakabindie Pastoral Lease. The 1990 proposal, referred to as the Yakabindie Nickel Project in Ministerial Statement 117, has not been implemented. The MKS Proposal constitutes a substantial revision of the 1990 proposal, requiring referral under section 38 and 40 of the *Environmental Protection Act 1986* (**EP Act**).

The MKS Proposal involves the development of two mine pits (Six Mile Well and Goliath), a waste rock landform, associated support infrastructure and a transport corridor between the Proposal and NMK. The Proposal will provide nickel disseminated sulphide ore to NMK for processing via existing processing and tailings storage facilities. The existing workforce and associated infrastructure will be utilised for the Proposal.

The Proposal was referred to the Western Australian EPA under s 38 of the EP Act on 3 May 2017. Upon receipt of required further information, on 19 July 2017, the EPA determined that the Proposal required an environmental assessment at Environmental Review – Environmental Review Document (**ERD**), with no public review period.

On 6 October 2017, NiW submitted a request to the EPA to make changes to the Proposal, comprising:

- increase of the Development Envelope from 1242ha to 1259 ha;
- increase of clearing footprint from 842 to 878 ha; and
- increase of water supply volume from 0.6 GL/a to 1.65 GL/a.

The EPA issued a Notice of Decision to Consent to a Change to Proposal during Assessment on 6 November 2017 enabling assessment of the Proposal with these changes. The final Proposal Development Envelope and Disturbance Footprint is shown in Figure ES2.

The EPA issued an Environmental Scoping Document (**ESD**) on 14 November 2017. This assessment addresses the environmental factors and work items raised in the ESD.

Overview of Proposal

A summary of the proposal and the key physical and operational characteristics is provided in Table ES1.

Table ES1 Proposal overview and key characteristics

Summary of the Proposal		
Proposal title	Mt Keith Satellite Project	
Proponent name	BHP Billiton Nickel West Pty Ltd	
Short description	The proposal is a satellite operation to the existing Mt Keith Mine and includes two open pits, a waste rock landform and a haul road corridor. Ancillary infrastructure that supports mining will be located at the satellite operation. The ore mined will be processed at the existing Mt Keith Mine located approximately 20 km north of the satellite operation. The proposal is located 80 km north of Leinster in the Shire of Leonora.	
Element	**Location**	**Proposed Extent**
Physical characteristics		
Mine pit (Goliath)	Figure ES2	Clearing of approximately 212 ha of native vegetation within a Development Envelope of 1259 ha, mining in three stages within a 12 year timeframe.
Mine pit (Six Mile Well)		
Waste Rock Landform		Clearing of approximately 445 ha of native vegetation within a Development Envelope of 1259 ha.
Ancillary support infrastructure		Clearing of approximately 137 ha of native vegetation within a Development Envelope of 1259 ha.
Haul Road	Figure ES3	Clearing of approximately 84 ha of native vegetation within a Development Envelope of 1259 ha.
Operational elements		
Pit dewatering	Figure ES2	Water abstraction of up to 0.4 GL per year. Dewatering via bore(s) and pit sumps.
Bore field supply	NA	Up to 1.65 GL per year from existing licensed fields.
Waste	Figure ES2	Up to 800 Million tonnes of waste rock to be generated over the life of mine, to be stored in a Waste Rock Landform and used as backfill.

This ERD provides supporting information to the EPA to enable it to undertake its assessment under s 38 of the EP Act. The scope of this ERD is defined by the ESD and provides environmental impact assessment of the following key environmental factors:

- flora and vegetation;
- terrestrial fauna;
- subterranean fauna;
- hydrological processes;
- inland waters environmental quality; and
- social surroundings.

Other environmental factors addressed in this report include waste disposal in accordance with existing Mt Keith Mine approvals, including Ministerial Statement 415; greenhouse gas emission and mine closure planning.

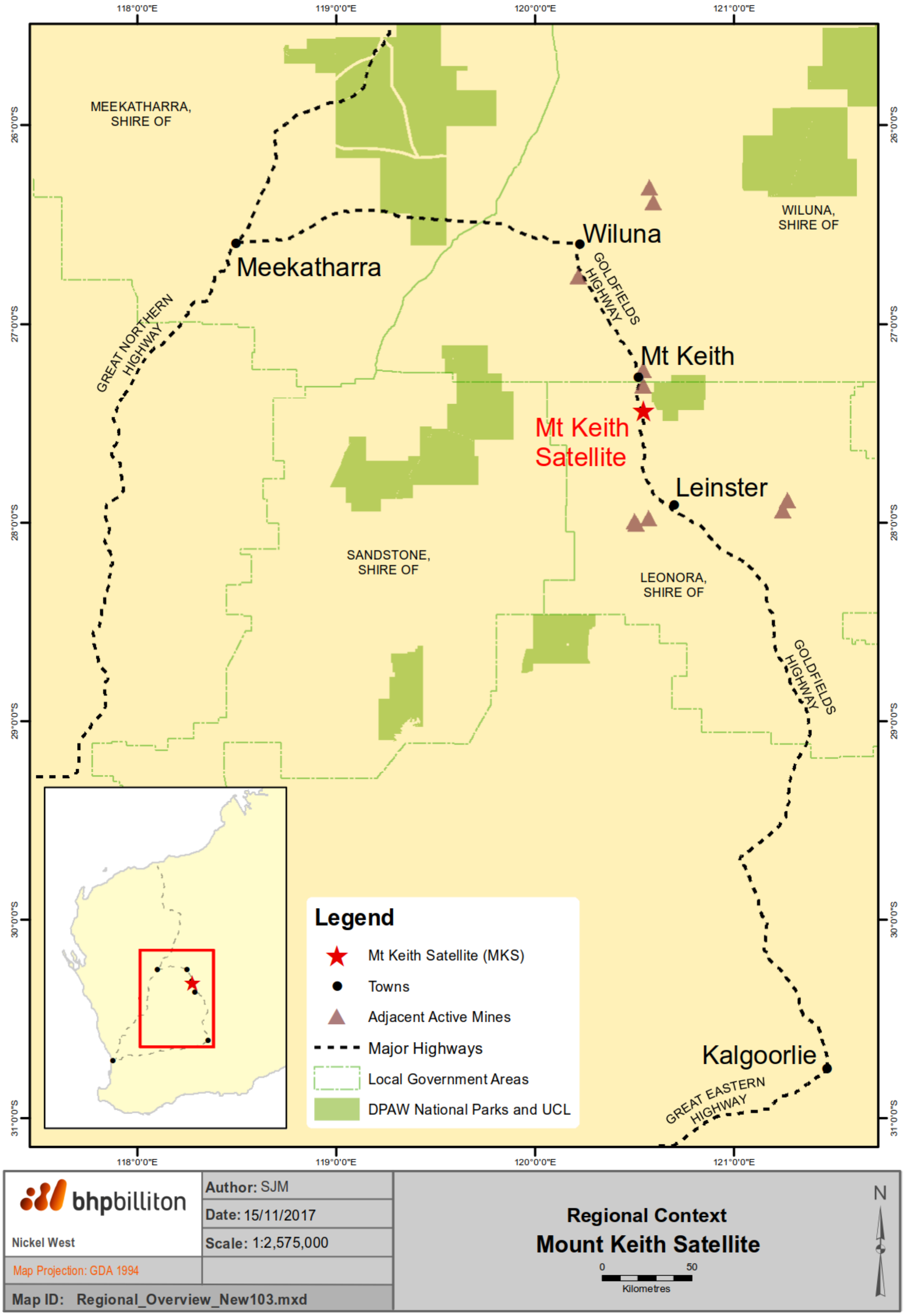

Figure ES1: MKS Regional Context

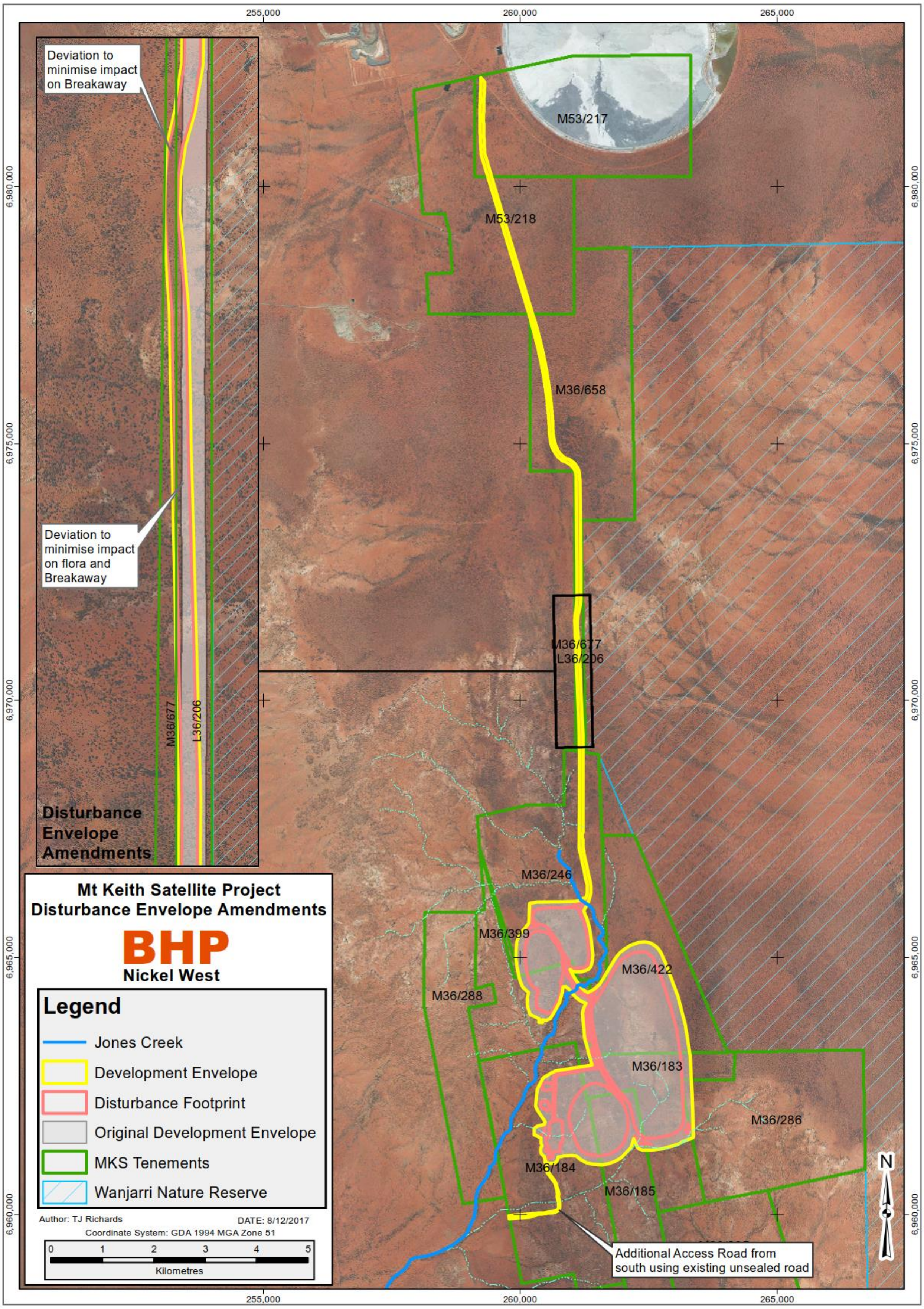

Figure ES2: MKS Proposal Development Envelope and Disturbance Footprint

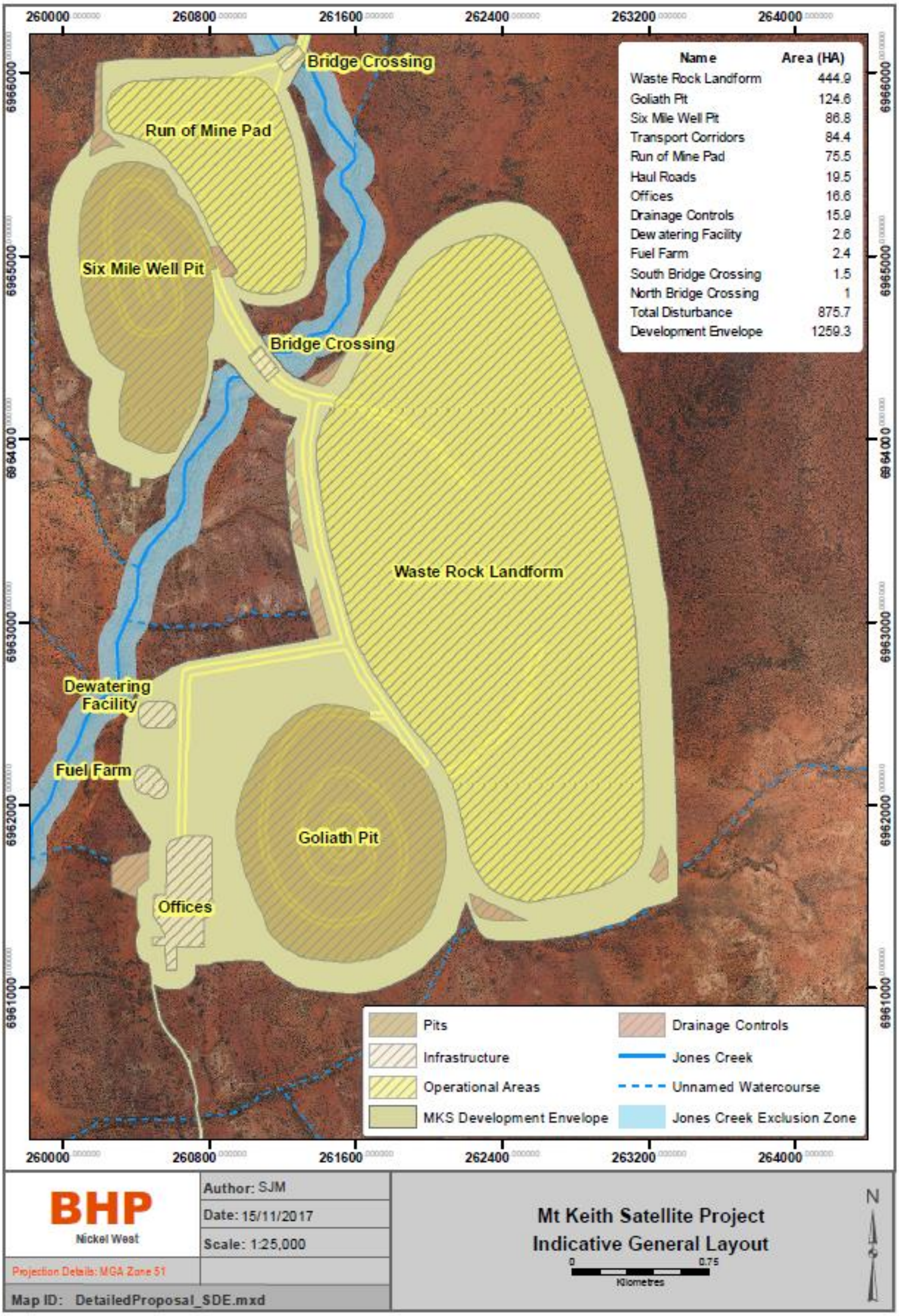

Figure ES3: MKS Proposal Indicative General Layout

Summary of Potential Impacts, Proposed Mitigation and Outcomes

This document provides information about the existing environment and potential impacts of implementation of the Proposal, in a local and regional context. This ERD explains NiW's management approach to potential impacts for each of the EPA's preliminary key environmental factors identified for the Proposal. A summary of the environmental review is provided in Table ES2.

NiW has given due regard to the principles of ecological sustainable development of the EP Act and relevant EPA and other environmental guidelines in this assessment.

NiW has extensive data sets and proven current management practices on which the EIAs were based, resulting in a high level of confidence in impact predictions. Where inherent impacts have been assessed as significant the application of the mitigation hierarchy has resulted in a reduction of potential impacts to a level NiW considers reasonable.

The EIA undertaken by NiW for this Proposal has concluded that for all factors outlined in the environmental scoping document, the EPA objectives can be met and the residual impacts to the environment resulting from the Proposal are not significant. NiW considers that the information and assessment presented in this ERD adequately identifies and addresses environmental impacts relevant to the Proposal, adequately addresses the environmental scoping document and is suitable to enable the EPA to undertake its EIA of the Proposal.

Table ES2 Summary of Environmental Impact Assessment for Key Environmental Factors

Environmental Factor: Flora and Vegetation		**EPA Objective:** To protect flora and vegetation so that biological diversity and ecological integrity are maintained	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The Study Area is located within the eastern portion of the Murchison Biogeographic Region and the East Murchison (MUR1) subregion. No Threatened (Declared Rare) flora is known within the Study Area. Fourteen Priority flora are known within the Study Area (one P1, two P2, eight P3 and three P4 species). The majority of species known from the overall Study Area are both common and widespread in the eastern Murchison, western Great Victoria Desert biogeographic regions. No Threatened Ecological Community (TEC) is known within the Study Area. The Study Area lies approximately centrally within the Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation) Priority 1 Priority Ecological Community.	Clearing of up to 878 ha within Development Envelope of 1259 ha. Loss of native vegetation communities. Loss of Priority flora. Loss and/or fragmentation of vegetation communities, particularly those of the Violet Range PEC, Wanjarri Nature Reserve and conservation significant species. Altered fire regime and associated change and/or loss of vegetation. Dust from mining activities resulting in reduced health and condition or loss of significant flora, including vegetation within Wanjarri Nature Reserve. Mining activities resulting in increased spread of weeds and potential for cumulative impacts such as altered fire regimes	**Avoid** Disturbance footprint designed to reduce disturbance to Priority flora. Vegetation clearing to be limited to Proposal Disturbance Footprint, with no clearing or mining activities to occur within Wanjarri Nature Reserve Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to individuals of the P2 flora Hibbertia sp. Sherwood Breakaways. Waste Rock Landform design will avoid direct impact to individual *Hibiscus krichauffianus* (P3) **Minimise** Land disturbance kept to minimum necessary for development of the Proposal within the design footprint. Existing internal ground disturbance procedures and permitting system will be implemented (“Environmental and Heritage Impact Approval” process). Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. Dust suppression, including use of water carts on access roads, to be used during construction, operation and closure activities. Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to MKS via transport route. Implement similar minimum biannual weed monitoring and targeted spraying program at MKS following completion of land clearing activities and during operations and closure activities. Firefighting equipment will be located on site and emergency personnel will be trained in fire response.	The following residual impacts are considered to be of minor significance at both local and regional scale: Clearing will necessitate the removal of a number of conservation significant plants from the Disturbance Footprint. Minor disturbance to Jones Creek will occur in the formation of two creek crossings. Remaining riparian vegetation will not be disturbed. Clearing will directly impact 3.76% of the Violet Range PEC (Disturbance Footprint) with possible indirect impacts up to 5.24% (Development Envelope). Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. No direct impacts on the Wanjarri Nature Reserve will occur. NiW considers that clearing required for the Proposal will not have significant residual impacts and meets the objective for this factor.

		A Hot Work Permit system will be implemented. All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. Proposal site induction to include information on prevention and management of fires. Clearing, topsoil stripping and stockpiling will be undertaken in accordance with NiW procedures. Undertake monitoring and adaptive management in accordance with the Flora and Vegetation Environmental Management Plan (Appendix C) **Rehabilitate** Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	
Environmental Factor: Terrestrial Fauna		**EPA Objective:** To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Eight terrestrial vertebrate fauna habitats were described for the Study Area based on vegetation mapping, geology, landform and soils. These include: Hills and Slopes, Sclerophyll Shrublands Undulating Plains, Sclerophyll Shrublands Drainage tract – Mulga Undulating Plains Grass Dominated Undulating Plains – Chenopod Shrublands Areas of Internal Drainage – Mulga Drainage Line Hills and Slopes, Chenopod Shrublands None of the fauna habitats are restricted to this area, based on the broader distribution of vegetation communities and land system types.	Clearing of native vegetation resulting in loss and/or fragmentation of faunal (terrestrial and SRE invertebrate) habitat altered fire regime and associated change and/or loss of vegetation; and loss of native seedbank Loss of creekline habitat in Jones Creek due to construction of two creek crossing Mining activities resulting in increased spread of weeds. Light, noise and vibration resulting in changes in faunal behaviour and community structure. Dust from mining activities resulting in reduced vegetation health and condition. Increase in sediment load to Jones Creek resulting in sedimentation downstream	**Avoid** Disturbance footprint designed to reduce disturbance to conservation significant flora. Vegetation clearing to be limited to Proposal Disturbance Footprint, with no clearing or mining activities to occur within Wanjarri Nature Reserve. Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to Sherwood Breakaways habitat and Areas of Internal Drainage - Mulga habitat. **Minimise** Land disturbance, including within Jones Creek for creek crossing construction, kept to minimum necessary for development of the Proposal within the design footprint. Existing internal ground disturbance procedures and permitting system will be implemented. Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. Dust suppression, including use of water carts on access roads, to be implemented during all Proposal phases.	The following residual impacts are considered to be of minor significance at both local and regional scale. Clearing will necessitate the removal of some vertebrate and SRE invertebrate faunal habitat. Minor disturbance (1.4%) to Eucalyptus dominated ephemeral drainage line habitat within Jones Creek will occur in the formation of two creek crossings. Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. No direct impacts on the Wanjarri Nature Reserve will occur. While the vegetation of the Study Area plays a role in providing fauna habitat, none of the Vegetation Associations that are significantly impacted in development of the MKS Proposal are known to provide habitat critical to the maintenance of fauna species. The proposed development has been designed to minimise impacts to the eucalypt dominated ephemeral drainage line of Jones Creek, which is considered to be the most significant of habitats from a short-range endemic fauna utilization and refuge perspective. The impact on the riparian vegetation is

The 28 fauna survey sites within the Study Area have yielded 135 vertebrate species, comprising 17 mammals, 77 birds and three frogs. A number of conservation significant species have been recorded in the vicinity of the Development Envelope (e.g. Night Parrot, Black-footed Rock-wallaby, Mallee Fowl). Recent survey efforts did not record any of these species in the Development Envelope or the wider Study Area.		Lighting designed to illuminate designated operations areas rather than the surrounding landscape. Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to MKS via transport route. Implement biannual weed monitoring and targeted spraying program at MKS following completion of land clearing activities and during operations and closure activities. Firefighting equipment will be located on site and emergency personnel will be trained in fire response A Hot Work Permit system will be implemented. All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. Proposal site induction to include information on prevention and management of fires Putrescible waste materials to be stored in bins with lids and transferred to Mt Keith operations for disposal No feeding of native animals Designated speed limits on access and haul roads to reduce fauna strikes Removal of dead fauna away from edges of roads Mitigation actions for creek crossings within Jones Creek discussed in Section 8. **Rehabilitate** Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	restricted to creek crossings, with remaining riparian vegetation undisturbed and is considered to be minor. A risk assessment of potential impacts was undertaken based on known distribution, records from within the Study Area, suitable habitat and likelihood of occurrence. In all cases for Priority species that may occur within the Development Envelope, the risk have been assessed as low. The remaining available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of conservation significant vertebrate and SRE invertebrate species. NiW considers that the Proposal meets the objective for this factor.
Environmental Factor: Subterranean Fauna		**EPA Objective:** To protect subterranean fauna so that biological diversity and ecological integrity are maintained	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The geology of the Project area is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite,	Removal of habitat through excavation of the proposed mining pits, Goliath and Six Mile Well; and Drying out of habitat through the lowering of the groundwater table associated with mine pit dewatering.	**Avoid** Avoidance and minimisation measures to mitigate the impacts of mining excavation and associated groundwater drawdown on components of the subterranean fauna assemblage recorded are limited. Proposed mining areas are well defined that will insure	The proposed development of the Goliath and Six Mile Well pits are not considered to represent a significant residual impact to the stygofauna values recorded from parts of the Study Area. Under the residual impact significance model the proposed areas of impact associated with the development of Goliath and Six Mile Well pits are not

which host the nickel sulphide deposits (MWES Consulting 2017b). The Proposal is located within the upper catchment of the Jones Creek which is a lateral tributary system, incised into the Barr-Smith Range. The majority of runoff for this ephemeral water course is received from the upper catchment, which covers an area of 64.1 km2. In large flood events, water is rapidly shed from this part of the catchment into the creek, aided by the rocky nature of the terrain. The terminus for the creek is a large floodplain area to the south west, containing a number of claypans (MWES Consulting 2017b). Beyond this, drainage becomes increasingly diffuse, before encountering the Yakabindie calcrete and reaching Lake Miranda, located within the Carey Palaeodrainage system (Wetland Research and Management 2005) (Stantec, 2017b). This catchment lies within the larger catchment of an ancient river system, the Carey Palaeodrainage, which once flowed south east into the Eucla Basin. Major fresh and hypersaline aquifers are contained within the palaeodrainage ground waters. Groundwater resources within the Carey Palaeodrainage catchment include calcrete, fractured rock and unconfined regolith (alluvial and colluvial) aquifers, a number of which are important in maintaining local stygofauna assemblages (Outback Ecology 2008, 2012a, b, d, Subterranean Ecology 2011a, Wetland Research	Changes to groundwater quality and chemistry through increase in sediment load in run-off from mine associated activities into tributaries leading to reduction in surface to groundwater infiltration rates lessening influx of resources (e.g. nutrients, oxygen); and Contamination of groundwater by fuel spills.	only target areas will be disturbed, thereby limiting impact area to proposed limits. Goliath pit and the northern portion of the Six Mile Well pit were found to not host suitable subterranean fauna habitat. Dewatering will be limited to the extent that is required for mining to occur. Construction and maintenance of surface water drainage systems to control and contain run-off from mining areas and divert clean stormwater away from pits and other mining disturbance areas. Drainage alongside transportation corridor to control run-off and divert clean stormwater away from access ways and topsoil stockpiles. Fuel storage to be maintained with self bunded facilities. Hydrocarbon contaminated soil and materials to be removed for disposal or remediation Avoidance of Jones Creek riparian zone other than for creek crossings. **Rehabilitation** The specific rehabilitation of subterranean fauna habitat has not been attempted before and will not be attempted for the Goliath and Six Mile Well pits. Post cessation of mining, Six Mile Well pit will be completely backfilled so groundwater levels will return close to baseline levels in the long term. Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). **Likely Rehabilitation Success** It is not expected that the depauperate subterranean fauna environmental values would return within the backfilled pit area. However, outside of the backfilled mine pit within the groundwater drawdown impact zone, subterranean fauna environmental values are considered likely to recover with natural restoration of groundwater levels	recognised as hosting high biological values or representative of high biodiversity. In addition, the proposed impacts are not considered likely to result in any subterranean species being listed as specially protected or threatened. The proposed Project is considered to not pose a risk to the long-term survival of any known troglofauna species as no species were collected from the within the proposed impact areas. For stygofauna, the two stygobitic species, Atopobathynella sp. OES11 and Gomphodella sp. IK2, recorded from within proposed Six Mile Well groundwater drawdown impact areas only, are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The broader distributions of both species is supported by the wider distribution of *Atopobathynella* sp. OES8 and relatively high haplotype diversity of *Atopobathynella* sp. OES11. The development of the Six Mile Well and Goliath pits and associated dewatering is considered to not pose a long term conservation risk to stygofauna and that the EPA objective for this factor can be met. Nickel West considers that development of the Six Mile Well and Goliath pits and associated dewatering will not pose a long term conservation risk to stygofauna and that the EPA objective for this factor can be met.

and Management 2005). The greenstone landscape that dominates the Development Envelope is dissected by alluvial drainage lines (Stantec, 2017b). A number of stygofauna surveys have been undertaken in the area surrounding the Proposal (≤200 km), predominantly within calcrete associated groundwaters. Previous assessments have found that troglofauna do not represent a key environmental factor, and the focus of this assessment has therefore been on stygofauna species and habitat.			
Environmental Factor: Hydrological Processes		**EPA Objective:** To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The Proposal is located within a semi-arid zone, where surface flows are ephemeral and groundwater is limited due to geology. The Proposal pits will intersect groundwater resources. The geology of the Proposal Area is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite, which host the nickel sulphide deposits Regionally the Proposal is located within the Lake Miranda catchment, and locally is located within the upper catchment of Jones Creek. The terminus for Jones Creek is a large floodplain area in the valley floor to the south west, containing a number of claypans.	Impacts to the natural surface water flow as a result of placement, design and operation of mine pits and associated infrastructure Impacts to surface water resources, including Jones Creek, from alterations to surface water flows and groundwater drawdown Impacts to subterranean fauna as a result of groundwater drawdown and mounding	**Avoid** The Six Mile Well pit footprint has been designed such that Jones creek diversion is not required. Proposed mine layout is designed to lie outside of the flood zones. Jones Creek crossings constructed to avoid impact to natural flows. **Minimise** Design of single large waste rock landform minimises footprint and impact on catchment. Construction of clean water diversion drains impose volumetric limits on stormwater by the disturbed area, and maintains catchment flow. Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. Peak flood flow exclusion bund constructed at pit perimeter. Undertake monitoring of groundwater levels in the vicinity of Six Mile Well pit to confirm predicted extent of	The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. For the large majority of creek flow events, there is no potential interaction between the flood water and proposed major landforms (pits and dump). The potential for interaction only occurs in small areas at the margins of extreme flood levels which will occur briefly (less than one hour) and rarely (less than once in 50 years). A small amount of permanent bunding will securely isolate the Six Mile Well pit void from high-stage creek flow. The small incursions of the WRL onto the Jones Creek extreme flood zone are in areas of low stream velocity. Modelling has determined that catchment scale reduction in flow volume to be minor. Flow frequency and duration will be practically unaffected and total catchment discharge reduction will be approximately proportional to the catchment area reduction. Modelling shows that in most years that large scale catchment-wide flow occurs, the total annual yield greatly exceeds the capacity of the terminal Claypan such that the frequency of filling the Claypan will be barely diminished by the development. Road alignments have been adjusted to minimise impacts where possible and are not problematic from a hydrological perspective. Surface gradients along and across the proposed routes are generally low. Some relatively minor

		drawdown cone from dewatering and recovery of groundwater levels following completion of mining. Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline. Limit groundwater abstraction for Proposal water supply to pit dewatering, and existing NMK water supply (borefields and stormwater harvesting). Road design for haul route to include the following control measures: Breakaways - Grading exposes clay saprolite which may be to prone to erosion. Competent rock cladding of erosive material (clay saprolite) exposed in cuttings and in table drains on steeper sections, particularly within breakaways. Long slope-parallel sections - Erosion in the lateral table drain. Adequately close spacing of diversion drains. Oblique floodway crossings - Roadway capturing drainage. Additional sub-basecourse fill to raise the road profile on the down-slope size of the floodway Contour-parallel sections - Vegetation "shadowing". Eliminate windrows in areas where overland flow needs to be maintained including swales, floodways (specific drainage features) and other areas where vegetation appears to be enhanced by overland flow perpendicular to the roadway. Undertake monitoring and adaptive management in accordance with the Hydrological Processes Environmental Management Plan (Appendix D). **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). In particular, backfilling of the Six Mile Well Pit will allow full recovery of groundwater levels	drainage measures, cut slope cladding and road surface profile modifications cladding are detailed. Groundwater modelling shows that drawdown of 5 metres will extend up to several hundred metres beyond the pit crest. In the baseline condition minor aquifers are typically submerged (confined) by 20 metres such that at maximum Proposal drawdown, they will remain fully saturated, and hence practically unimpacted, well within the 5-metre drawdown contour extent. Surface vegetation is not considered to be groundwater dependent due to depth to water table and will not be affected by either dewatering of post-closure potential rise in water table of 0.6m above baseline. Groundwater mounding is not considered to be a significant residual impact. The two stygofauna species found within the drawdown impact zone are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The drawdown is not likely to pose a long term conservation risk to these species. The ERD demonstrates that the development of the pits and the wider Proposal will not significantly impact on either the short or long term hydrological regimes of groundwater and surface waters, ensuring environmental values are maintained through the application of appropriate mitigation measures. NiW considers that the EPA's objective for hydrological processes can be met.

Environmental Factor: Inland water environmental quality		**EPA Objective:** To maintain the quality of groundwater and surface water so that environmental values are protected	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Regionally the Proposal Development Envelope is located within the Lake Miranda catchment and at a local level, the upper reaches of the Jones Creek catchment. Jones Creek is an ephemeral water course which drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to a Claypan near the valley axis. Generally the baseline water quality is low salinity, low turbidity, low levels of nickel and zinc with elevated copper, exceeding the ANZECC (2000) 80% protection trigger level for fresh water. Baseline stream sediment is typically 85% sand sized particles and up to 1.2% clay sized particles. Metal concentrations are generally well below the sediment quality guideline low trigger value for aquatic ecosystems ANZECC, (2000), with the exception of chromium and nickel which have been recorded at values between the ANZECC low and high trigger values. Groundwater is relatively scarce in the Proposal area, and lies 15 to 35m below the Development Envelope. The quality ranges from brackish to saline, neutral to slightly alkaline, dissolved cadmium, chromium, lead, selenium and zinc mostly below detection limits, elevated levels of boron and slightly elevated levels of nickel and chromium concentrations associated with the Six Mile Well ultramafic and dunite respectively.	Sedimentation of Jones Creek due to contaminated stormwater runoff from mining areas Sedimentation of drainage lines due to erosions of haul road Contamination of surface water by hydrocarbons and chemicals Oxidation of sulphidic ore causing acidic drainage Seepage of water from pit lakes to local groundwater post closure Stock and/or native fauna access to pit lakes and risks to animals as well as increased grazing/ trampling pressure on surrounding vegetation Disturbance resulting in a temporary loss or shift in aquatic habitat from the two creek crossings Sedimentation affecting water quality and aquatic biota Changes in surface hydrology that influence the composition of aquatic biota. Contamination posing a potential ecotoxicity risk to aquatic biota	**Avoid** Landforms designed to lie outside of flood impact zones. Haul route directly departs from the Jones Creek catchment. With the exception of the road crossings, the nearest Proposal feature is approximately 50m from Jones Creek. **Minimise** Disturbance to aquatic habitat and riparian vegetation within Jones Creek limited to construction of the two road crossings, which will maintain flow. Construction of stormwater diversion drains to reduce volume of stormwater over disturbed areas, reducing potential sedimentation and contamination of the creek. Construction of dirty water capture drains to capture stormwater from disturbed areas to silt traps, preventing sedimentation and contamination of the creek. Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. Construction of clay bunds to prevent stormwater flow and contamination down creek lines blocked by the WRL. Coarse dumping of non-erodible/competent rock on the outer surface of the WRL. Peak flood flow exclusion bund constructed at south east pit perimeter of Six Mile Well pit. Divert dirty stormwater to silt traps and first flush check dams. Silt traps, check dams to be unlined to provide first flush storage capacity with overflow for ongoing runoff and designed to contain volume of 4mm runoff depth across sub-catchment.	The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. Segregation of clean and dirty stormwater is the primary mitigation measure to protect local surface water quality. Stormwater diversion away from mining infrastructure and capture and treatment of contaminated stormwater will be implemented. Potential acid forming material will be encapsulated with high acid neutralizing capacity within the WRL. Seepage from the backfilled Six Mile Well pit and the Goliath pit lake to groundwater will be minor and of similar quality to existing groundwater. It is not anticipated that this landform will increase fauna or stock activity in the area, as access will be prevented by bunding and fencing. NiW considers that the residual impacts of the Proposal on surface water and groundwater quality are not significant and can be managed through the implementation of the proposed mitigation measures. Accordingly NiW considers the Proposal meets the EPA objectives for this factor.

		Rock cladding of erosion prone slopes graded for haul road construction (breakaways and creek crossings). Coarse rock armour of the exposed toe segment (500m) to a height which exceeds the 100 year peak flood level. Identification of PAF waste during drill and blast cycles and encapsulation within a designated cell in the WRL. Self-bunded fuel and chemical storage facilities. Undertake monitoring of groundwater quality in the vicinity of Six Mile Well pit. Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline conditions (Appendix R). Post closure construction of abandonment bund and perimeter stock fencing around the final Goliath pit void and construction of bund across the top of pit access ramps and suitable egress point for fauna and stock (in the event abandonment bunds and fences are breached). Post closure diversion of diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks. **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	
Environmental Factor: Social Surroundings		**EPA Objective:** To protection social surroundings from significant harm	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Aspect: Aboriginal Heritage			
The Proposal Development envelope lies within the Tjiwarl determination area (WAD228/2011 and WAD302/2015). The Tjiwarl consist of multiple family groups. Over time (pre and post determination), NiW (and predecessor companies) have consulted with members of these family groups regarding Aboriginal	Loss/disturbance to identified and unidentified Aboriginal heritage sites Constraints on traditional cultural activities Interruption to access to the heritage sites Alterations to hydrological processes associated with Jones Creek	**Avoid** Mine design has considered the Aboriginal heritage within the Development Envelope and has been through a substantial number of versions balancing economic and cultural concerns. By relocating the waste rock landform, NiW has been able to avoid impacts to the Barr-Smith Range (from a mythological perspective).	Despite efforts to avoid or minimise impacts on Aboriginal heritage sites, the Proposal may have a residual impact on twenty-three known places within the area for which s 18 consent was obtained in 2003. The most significant cultural heritage landscape features in the vicinity are the Barr-Smith Range and Jones Creek. The Aboriginal heritage and cultural values of the Barr-Smith Range will not be directly impacted. Jones Creek will be directly impacted at two creek crossing locations. No other part of Jones Creek will be directly impacted by this

heritage and cultural values in and around the Development Envelope. These consultations have included the engagement of Tjiwarl family groups as well as other Aboriginal people with cultural knowledge of the Development Envelope in heritage surveys. This broad consultation has resulted in the collection of a large amount of information about Aboriginal heritage and cultural values for the Development Envelope including about dreaming mythologies such as the joint mythology of the Tjinkunya (Dragon Fly) and Tjila (Carpet Snake) Dreaming (the Tjinkunya Tjila Dreaming). A range of different views have been expressed over time about the cultural heritage values of the Development Envelope including but not limited to ethnographic Aboriginal sites (as defined by the Aboriginal Heritage Act 1972 (AH Act)). Key areas of Indigenous cultural and social significance are: the Barr-Smith Range; and Jones Creek. These areas, and places associated with them are significant to members of the Tjiwarl People. The mythological narrative is associated with the range area of the Barr-Smith Range.		With respect to Jones Creek, direct impact of the proposed Development Envelope is limited to two crossings of the creek to access the pits, WRL and ROM pad. **Minimise** The Disturbance Footprint has been minimised by generating engineering solutions which have permitted the Proposal to remain feasible while reducing impacts on environmental and cultural values. All ground disturbance activities will be approved through the NiW EHIA process prior to commencing. Outside of the existing s 18 approval area, if there was insufficient information regarding potential or known heritage and cultural values, this process triggers further study or investigation. NiW intends to work together with the Tjiwarl to manage cultural heritage within the Proposal area. To further this goal a CHMP will be developed and will address appropriate contingency actions. **Salvage** Any cultural material salvaged due to a request of the traditional owners or as a condition of s 18 consents will be relocated on country or moved to a suitable cultural repository 'holding place' until such time as the material can be returned to country. Other salvaging activities could include photographic recordings, test pitting and 3 dimensional aerial drone capture of the surrounding landscape. **Rehabilitation** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). Refinement of the final closure plans at the end of the mine life will be undertaken in consultation with the Tjiwarl.	Proposal. These crossings have been designed to minimise impact on flow through of the Creek and will not impact on creek flow through and the overall catchment drainage. The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. This will be managed through ongoing engagement with the Tjiwarl. Some restrictions to access for traditional and cultural purposes including hunting and gathering will be required during the construction and operation of the mine. However, the development of the CHMP for the proposed operations will detail land access protocols for traditional owners and serve to strengthen and extend the cultural and heritage links with the area. Establishing these links will enable both parties to respect and consider approaches to mitigate impacts to the tangible and intangible heritage of the Development Envelope. NiW believes that with the proposed mitigation measures, the EPA objective for social surroundings as it relates to Aboriginal heritage can be met.
Aspect: Wanjarri Nature Reserve			
The Proposal lies to the west of the Wanjarri Nature Reserve, with	Impacts on amenity values of Wanjarri Nature Reserve, including:	**Avoid**	Amenity values can be highly subjective, with different levels of perception or tolerance of impacts. The residual impact of

the main haul road to Mt Keith abutting the western boundary of the Reserve.	Dust, noise, vibration and light emissions impacting on amenity of visitors to Wanjarri Nature Reserve. Visibility of the final waste rock landform from within the Reserve Interruption to public access to the Reserve.	Provision of a safe, alternative access route into Wanjarri Nature Reserve. **Minimise** Use of water based dust suppression on haul road, access ways and within mining areas. Use of chemical stabilisation in water based dust suppression on haul road nearest the NMK camp Speed controls on vehicle movements along the haul road to minimise dust generation. Blasting charge sizes limited to ensure ground borne vibration levels remain within prescribed daytime and night-time limits as measured from the camping area within Wanjarri Nature Reserve. Lighting limited to illumination of operational areas for safety requirements. **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	noise, dust and light emissions on the amenity of the Wanjarri Nature Reserve are considered to be low: Noise emissions are expected to remain within prescribed limits for Wanjarri Nature Reserve. Blasting vibrations are not expected to impact on the reserve, with appropriate charge controls in place. Dust emissions are not expected to impact on visitor access to the Reserve and will be controlled along the western boundary of the Reserve where it abuts the haul road, through the use of water based dust suppression. Light emissions are expected to be limited to operational areas and rapidly dissipate with distance from the source. The most visible aspect of the Proposal will be the final waste rock landform. Visual impact assessment has found that it is likely this landform will be visible along some parts of the access into Wanjarri Nature Reserve inside the 10km viewshed, particularly where the vegetation is sparse. As vegetation density and distance increase, the landform is less visible. At key access points within the Reserve, being the Homestead and Shearing Shed, there is limited to no visibility of this landform. Continued, safe access to the Reserve will be maintained through an existing alternative access route. The residual impacts of the Proposal on the amenity values of Wanjarri Nature Reserve are minor and, with the exception of visibility of the final waste rock landform, can be mitigated with appropriate management measures. NiW considers that the EPA objectives for Social Surroundings as it relates to the values of Wanjarri Nature Reserve, can be met.

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Scoping Checklist

Task No	Required work	Section and Page No
EPA Factor 1: Flora & Vegetation		
1	Identify and characterise flora and vegetation in accordance with the standards of *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, December 2016). The detailed survey should take into account areas that are likely to be directly or indirectly impacted as a result of the proposal, including a linear corridor survey of the haul road between Mt Keith Mine and the proposal.	Section 5.2 p23-42
2	Undertake baseline mapping of weed affected areas in any area likely to be directly or indirectly impacted as a result of the proposal.	Section 5.3, p36-37, 42
3	Provide an analysis of flora and vegetation present within the Development Envelope and also present in the indirect areas of disturbance outside of the Development Envelope. Where relevant, include in this analysis the conservation significance of flora and vegetation in a local and regional context. Analysis of impacts on vegetation to include: • the area (in ha) of each vegetation unit to be impacted (directly and indirectly) in a 'worst case' scenario; • the total area (in ha) of each significant vegetation unit to be impacted (directly or indirectly) in a 'worst case' scenario; and • identification of vegetation units which may represent a component of threatened or priority ecological communities, including but not limited to, the Violet Range PEC. • Analysis of impacts on significant flora to include: • identification of any significant flora present or likely to be present; • the number of plants, and the number of populations of plants and habitat, to be impacted (directly or indirectly) as a result of the proposal in a 'worst case' scenario, i.e. if no mitigation measures were taken; • the total number of plants and populations within the local area or Study Area; and • a summary of the known populations of the species including distribution, number of populations and the number of plants or an estimate of the number of plants in the regional area.	Sections 5.2-5.4 p43-74
4	Provide tables and figures of the proposed direct impact, or predicted extent of loss, and the predicted indirect impact to flora and vegetation, including but not limited to threatened and/or priority ecological communities, potential groundwater dependent ecosystems, threatened flora, priority flora and unnamed or new flora species.	Section 5.3, p43-73
5	Provide a detailed description of the cumulative impacts associated with the proposal on flora and vegetation, including direct impacts from clearing, and indirect impacts such as groundwater drawdown, altered drainage, changes in water quality, spread of weeds, fragmentation of vegetation, altered fire regimes, and dust.	Section 5.3, p43-73

Task No	Required work	Section and Page No
6	Discuss and determine significance of potential direct, indirect (such as dust, downstream impacts, and weed invasion, etc.) and cumulative impacts to flora and vegetation as a result of the proposal at a local and regional level.	Section 5.3, p43-73
7	Discuss management measures, outcomes/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 5.5, p73-74
8	Demonstrate that all practicable measures have been taken to reduce both the area of the proposed Disturbance Footprint and the Development Envelope based on progress in the proposal design and understanding of the environmental impacts.	Section 2.3, p13-15 Section 5.5, p73-74
9	Provide a Flora and Vegetation management plan to address significant residual impacts to flora and vegetation. The following should be addressed in the plan: • invasive species control - control of weeds, in particular through construction of infrastructure, transport and/or entry and exit points, vegetation units considered to have high local significance (e.g. rare units, habitat for conservation significant species) and in areas identified as in 'Excellent Condition'; • monitoring program - to monitor the significant flora and vegetation communities identified; • management program - develop adaptive management actions to be triggered should monitoring show a decline as a result of implementing the proposal; • rehabilitation and closure – to address potential indirect impacts persisting after mining has finished (e.g. pit lakes); and • management of offset (if applicable).	Appendix C
10	Prepare a Mine Closure Plan consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2015), which includes methodologies and criteria to ensure progressive rehabilitation of disturbed areas to a final agreed land use.	Appendix E
11	Predict the inherent and residual impacts before and after applying the mitigation hierarchy.	Section 5.5, p73-74
12	Describe proposed monitoring and management (in terms of the mitigation hierarchy) to achieve the predicted outcomes/objectives.	Section 5.5, p73-74
13	Determine and quantify any significant residual impacts by applying the Residual Impact Model and WA Offset Template in the WA Environmental Offsets Guidelines.	Section 5.5, p73-74
14	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and WA Environmental Offsets Guidelines. Spatial data defining the area of significant residual impacts should also be provided.	Section 5.5, p73-74 Section 12.3, p236-252
15	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 5.5, p73-74
EPA Factor 2: Terrestrial Fauna		
16	Provide a desktop review and analysis of all surveys of the proposal area undertaken, in accordance with EPA policy and guidance. The study should include:	Section 6.2, p76-109

Task No	Required work	Section and Page No
	• a justification of how those surveys are relevant and representative of the Development Envelope and if they were carried out using methods consistent with the EPA guidance; and • a comprehensive listing of vertebrate fauna and SRE invertebrate fauna known or likely to occur in the habitats present, and identification of conservation significant fauna species likely to occur in the area.	
17	Conduct Level 2 terrestrial fauna and SRE invertebrate surveys in areas that are likely to be directly or indirectly impacted as a result of the proposal. Surveys are to be undertaken in accordance with EPA policy and, where available, species-specific survey guidelines for relevant species listed under the *Wildlife Conservation Act 1950* and the *Environment Protection Biodiversity Conservation Act 1999*.	Section 6.2, p76-109
18	Conduct targeted surveys for conservation significant fauna that are known to or likely to occupy habitats in the Proposal area if demonstrated to be required based on the results of the desktop study and field surveys.	Section 6.2, p76-109
19	For each relevant conservation significant species, including SREs, identified as likely to occur within the proposal area, provide: • baseline information on distribution (including known occurrences), ecology, and habitat preferences at both the site and regional levels; • size and the importance of the population from a local and regional perspective and potential percentage loss of the conservation significant species locally due to loss of habitat; and • maps illustrating the known recorded locations of conservation significant species and SRE invertebrates in relation to fauna habitat and the proposed disturbance and areas to be impacted.	Section 6.2, p76-109
20	Identify the fauna habitat types within and outside the areas of impact. Consider habitat types that provide important ecological function within the proposal area (e.g. geological features which may support unique ecosystems) and the conservation value of each habitat type from a local and regional perspective.	Section 6.2, p76-109
21	Assess the extent of direct and indirect disturbance, including percentages of habitat types to be disturbed or otherwise impacted, to assist in determination of significance of impacts. Information, including maps, must also differentiate habitat on the basis of use e.g. breeding habitat, migration pathways, and foraging/feeding/dispersal habitat. Consider whether the remaining habitat has adequate carrying capacity.	Section 6.4, p110-120
22	Describe and assess the significance of the potential direct, indirect (including downstream) and cumulative impacts as a result of the proposal on terrestrial fauna at a local and regional scale.	Section 6.4, p110-120
23	For all conservation significant species that are not likely to be impacted by the proposed action, but for which suitable habitat is present which could be impacted by the proposed action, include enough information to demonstrate that an impact on the species will not or is unlikely to occur.	Section 6.4, p110-120
24	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to terrestrial fauna.	Section 6.5, p121-122

Task No	Required work	Section and Page No
25	Discuss the management and mitigation measures, outcomes/objectives sought to ensure direct and indirect residual impacts (following management and rehabilitation actions) are not greater than predicted.	Section 6.5, p121-122
26	Prepare a Mine Closure Plan consistent with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2015), which addresses the need for progressive rehabilitation of habitat for conservation significant species.	Appendix E
27	Predict the inherent and residual impacts before and after applying the mitigation hierarchy.	Section 6.5, p121-122
28	Describe proposed monitoring and management (in terms of the mitigation hierarchy) to achieve the predicted outcomes/objectives.	Section 6.5, p121-122
29	Determine and quantify any significant residual impacts by applying the Residual Impact Model and WA Offset Template in the WA Environmental Offsets Guidelines.	Section 6.5, p121-122 Section 12.3, p236-252
30	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and WA Environmental Offsets Guidelines. Spatial data defining the area of significant residual impacts should also be provided.	Section 6.5, p121-122 Section 12.3, p236-252
31	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 6.5, p121-122
EPA Factor 3: Subterranean Fauna		
32	Undertake a desktop study to document the regional context of the subterranean fauna of the proposal area including, but not limited to, existing regional subterranean fauna surveys, and assessment of the likely presence and characteristics of subterranean fauna habitat.	Section 7.2, p125-140
33	Conduct Level 2 surveys inside and outside areas subject to direct and indirect impacts, in accordance with EPA policy and guidance.	Section 7.2, p125-140
34	Present the results of all relevant subterranean fauna surveys. Include comprehensive mapping of the distributions of species in relation to the proposed disturbance (including groundwater drawdown), and of the geology or hydrology predicted to support subterranean fauna habitats (including its extent outside the Development Envelope).	Section 7.2, p125-140
35	Discuss habitat prospectivity and demonstrate habitat connectivity within and outside the proposed Disturbance Footprint.	Section 7.2, p125-140
36	Identify and assess the potential direct, indirect, and cumulative impacts of the proposal on subterranean fauna, within the proposal area and regionally. Consider temporary (e.g. construction) vs ongoing (e.g. operations) impacts, including altered water regimes and water quality.	Section 7.4, p140-142
37	For taxa that may be impacted, provide information, including maps, on habitat connectivity and an explanation of the likely distribution of species within those habitats. Provide detailed descriptions of potential impacts to conservation significant species.	Section 7.2-7.4, p125-142
38	Identify any limitations associated with the survey data or existing knowledge and discuss their implications for the impact assessment.	Section 7.2, p140 Appendix L

Task No	Required work	Section and Page No
39	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to subterranean fauna.	Section 7.5, p142-143
40	Discuss proposed management objectives, measures, and outcomes sought to ensure residual direct and indirect impacts are not greater than predicted.	Section 7.5, p142-143
41	Predict the inherent and residual impacts before and after applying the mitigation hierarchy.	Section 7.5, p142-143
42	Describe proposed monitoring and management (in terms of the mitigation hierarchy) to achieve the predicted outcomes/objectives.	Section 7.5, p142-143
43	Determine and quantify any significant residual impacts by applying the Residual Impact Model and WA Offset Template in the WA Environmental Offsets Guidelines.	Section 7.5, p142-143
44	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and WA Environmental Offsets Guidelines. Spatial data defining the area of significant residual impacts should also be provided.	Section 7.5, p142-143
45	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 7.5, p142-143 Section 12.3, p236-252
EPA Factor 4: Hydrological Processes		
46	Characterise the baseline hydrological and hydrogeological regimes and water quality, both in a local and regional context, including, but not limited to, water levels, water chemistry, stream flows, flood patterns, and water quantity and quality. This is to include a detailed description of the geological framework within the zone impacted by groundwater abstraction and any interdependence between surface and groundwater features/bodies.	Section 8.2, p145-159
47	Provide a detailed description of the design and location of the proposal with the potential to impact surface water or groundwater, including but not limited to, the two creek crossings over Jones Creek and abstraction bore locations.	Section 8.2, p145-159
48	Provide a detailed description of any investigations undertaken to determine potential impacts of proposed abstraction on the aquifer, environment and surrounding users (e.g. investigations via drilling of production and monitoring bores, test pumping, geophysical logging and chemical analysis of groundwater).	Sections 8.3-8.4, p160 -172
49	Provide a conceptual model of the surface and groundwater systems incorporating the results of monitoring conducted, including the extent of connectivity between surface and groundwater systems.	Section 8.2, p145-159
50	Provide a conceptual mine water balance over the life of the proposal to discuss the capacity to reuse surplus mine dewater.	Section 8.2, p145-159
51	Discuss the potential environmental impacts and benefits of identified surplus water management options (i.e. discharge of excess mine dewater, reuse on site, local water supply, aquifer recharge etc.) and discuss the most appropriate water management strategy for the proposal.	Sections 8.3-8.4, p160 -172

Task No	Required work	Section and Page No
52	Model the impact of different flooding scenarios during operations and post-closure on infrastructure and final landforms.	Section 8.4, p160-172
53	Investigate groundwater drawdown due to groundwater abstraction associated with the proposal. Analyse, discuss and assess surface water and groundwater impacts. The analysis should include: • changes in groundwater levels and changes to surface water flows associated with the proposal; • the nature, extent and duration of impacts; and • cumulative impacts with other Proposals and referred proposal, for which relevant information is publicly available.	Section 8.4, p160-172
54	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Hydrological Processes.	Section 8.5, p172-175
55	Prepare a Mine Closure Plan consistent with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2015) which addresses the development of completion criteria to maintain the hydrological regimes of groundwater and surface water so that environmental values are maintained post closure.	Appendix E
56	Provide a description of monitoring, management, closure and rehabilitation arrangements and attach a management plan.	Appendices D, E
57	Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Appendix D
58	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 8.5, p172-175 Section 12.3, p236-252
EPA Factor 5: Inland Water Environmental Quality		
59	Characterise the baseline surface water and groundwater quality and quantity, both in a local and regional context, including but not limited to, water levels, water chemistry, spring and stream flows, flood patterns and catchment boundaries. This is to include a detailed description of the geological framework within the zone to be impacted by groundwater abstraction and any interdependence between surface and groundwater features/bodies. Include, where relevant influences on water availability.	Section 8.2, p145-159 Section 9.2, p176-177
60	Provide a detailed description of the design and location of the proposal with the potential to impact surface water and groundwater quality, including but not limited to, utilisation and storage of chemicals and/or hydrocarbons.	Sections 9.3-9.4, p177 -183
61	Identify a suitable water source and discuss the potential direct and indirect impacts. Identify contingency options and discuss the impact of each option.	Section 9.4, p177-183
62	Document any potential pathways for contamination to occur, including but not limited to, dust from the Run-Of-Mine pad, operational leaks and spills, drainage from and erosion of WRL surfaces and contamination from the final void pit lake.	Section 9.4, p177-183
63	Provide a conceptual mine water balance over the life of the proposal and discuss the capacity to reuse surplus mine dewater.	Section 9.4, p177-183

Task No	Required work	Section and Page No
		Appendix N
64	Provide an assessment on the physical and chemical characteristics of the proposed WRL and pit lake.	Section 9.4, p177-183 Appendices N, P
65	Undertake a pit lake risk assessment to determine the potential impact to hydrological processes and surface water from Acid and/or Metalliferous Drainage (AMD).	Section 9.4, p177-183 Appendices N & P
66	Analyse, discuss and assess surface water and groundwater impacts. The analysis should include but not be limited to: • changes in groundwater levels and changes to surface water flows associated with the proposal; • the nature, extent, and duration of impacts; • the impact of changing water quality or sources on environmental values; and • cumulative impacts with other Proposals and referred proposals, for which relevant information is publicly available.	Section 9.4, p177-183
67	Analyse, discuss implications of water filled pit lakes on values (particularly biological) both directly and in the surrounding environment.	Section 9.4, p177-183
68	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Inland Waters Environmental Quality.	Section 9.5, p183-185
69	Prepare a Mine Closure Plan consistent with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2015) which addresses the development of completion criteria to maintain the quality of groundwater and surface water, and management or removal of artificial sources (i.e. pit lakes), so that environmental values are maintained post closure.	Appendix E
70	Provide a description of monitoring, management, closure and rehabilitation arrangements.	Appendix E
71	Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Section 9.5, p183-185
72	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 9.5, p183-185 Section 12.3, p236-252
EPA Factor 6: Social Surroundings		
73	Characterise the heritage and cultural values of the Development Envelope and any other areas that may be indirectly impacted to identify sites of significance and their relevance within a wider regional context.	Sections 10.3-10.5, p187-193 Section 10.9-10.10, p196-211

Task No	Required work	Section and Page No
74	Characterise the land use and amenity values of Wanjarri Nature Reserve particularly noting important areas for human use that could be affected by noise, dust and light-spill emissions, visual amenity issues and access to the reserve from mining.	Sections 10.9-10.10, p196-211
75	Conduct Aboriginal heritage surveys to identify Aboriginal heritage sites of significance and identify concerns in regard to impacts from proposed mining operations.	Sections 10.4-10.6, p188-193
76	Provide a detailed description of the heritage and amenity values of the Development Envelope, Jones Creek, and the Wanjarri Nature Reserve, and provide a figure(s) of the heritage locations and proposed disturbance.	Sections 10.3-10.5, p187-193 Sections 10.9-10.10, p196-211
77	Provide details of consultation with Traditional Owners to determine appropriate management of culturally sensitive areas.	Section 10.7, p193-194
78	Provide details of consultation with the Department of Biodiversity, Conservation and Attractions to determine appropriate management of impacts to the Wanjarri Nature Reserve.	Section 10.10, p210-211
79	Assess the impacts of the proposal on heritage sites and/or cultural associations as a result of implementation of the proposal, including those arising from changes to the environment which may impact on ethnographic and archaeological heritage significance.	Sections10.5-10.6, p189-193
80	Predict the residual impacts on heritage and amenity, for direct, indirect and cumulative impacts after considering avoidance and minimisation measures.	Section 10.8, p194-195 Section 10.11, p212-213
81	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts to heritage and amenity (direct and indirect) are not greater than predicted.	Section 10.8, p194-195 Section 10.11, p212-213
82	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 10.8, p194-195 Section 10.11, p212-213 Section 12.3, p236-252

Terms, Definitions and Abbreviations

Term	Definition
AH Act	Aboriginal Heritage Act 1972
ANC	Acid neutralising capacity
bgl	Below ground level
BoD	Basis of design
CDTSF	Central discharge tailings facility
CHMP	Cultural heritage management plan
CO_2-e	Carbon dioxide equivalent
DBCA	Department of Biodiverstiy, Conservation and Attractions
DMIRS	Department of Mines, Industry Regulation and Safety
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EIA	Environmental impact assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection Biodiversity Conservation Act 1999*
ERD	Environmental review document
ESD	Environmental scoping document
Gl	gigalitres
Gl/a	gigalitres per annum
GWL	Groundwater well licence
kL	kilolitres
km	kilometres
km^2	Square kilometres
m	metres
mbgl	metres below ground level
mbSWL	metres below standing water level
MKS	Mt Keith Satellite
MPA	Maximum potential acidity
Mtpa	Million tonnes per annum

Term	Definition
NAF	Non-acid forming
NAPP	Net acid producing potential (MPA-ANC)
NMK	Mount Keith Nickel Operation
PAF	Potentially acid forming
RIWI Act	*Rights in Water and Irrigation Act 1914*
ROM	Run of mine
uS/cm	Microsiemens per centimetre
WC Act	*Wildlife Conservation Act 1950*
WRL	Waste rock landform
YNP	Yackabindie Nickel Project
ZoI	Zone of impact

1 Introduction

1.1 Purpose and scope of the ERD

BHP Billiton Nickel West (**NiW**) proposes to develop the Mt Keith Satellite Proposal (MKS **Proposal**), approximately 80 km north of Leinster in the Shire of Leonora and 20 km south of the Mt Keith Mine (Figure 1). The proposal is located within granted mining leases held by either BHP Billiton Nickel West Pty Ltd (**Proponent**) or its wholly owned subsidiary BHP Billiton Yakabindie Nickel Pty Ltd (Figure 2); and the Yakabindie Pastoral Lease, which is held by NiW (Figure 2). Portions of this Pastoral Lease are sublet to a third party for the conduct of pastoral activities.

The Proposal has a Disturbance Footprint of 878 ha within a Development Envelope of 1259 ha and involves the development of two mine pits (Six Mile Well and Goliath), a waste rock landform (**WRL**), associated support infrastructure and a 20 km transport corridor north to the existing Mt Keith Mine (Figure 3). The Proposal will use facilities at the existing Mt Keith Mine, including ore processing and storage of tailings, which are not a part of this Proposal.

This Environmental Review (**ERD**) provides supporting information to the EPA to enable it to undertake its assessment under s38 of the *Environmental Protection Act 1986* (**EP Act**). The scope of this ERD is defined by the Environmental Scoping Document (**ESD**) approved by the Chairman, Environmental Protection Authority on 14 November 2017, and provides environmental impact assessment of the following key environmental factors:

- Flora and vegetation
- Terrestrial Fauna
- Subterranean Fauna
- Hydrological Processes
- Inland Waters Environmental Quality
- Social Surroundings.

Other environmental factors addressed in this report include waste disposal in accordance with existing Mt Keith Mine approvals, including Ministerial Statement 415; and greenhouse gas emissions.

1.2 Proponent

The proponent of the proposal is:

BHP Billiton Nickel West Pty Ltd
ABN: 76 004 184 598
ACN: 004 184 598
125 St Georges Terrace
PERTH WA 6000

Enquiries regarding the proposal can be directed to the contact details provided below:

BHP Nickel West
Land Services
PO Box 8301
Perth Business Centre WA 6849
Tel: 61 8 6321 3979
Email: NickelWestGLS@bhpbilliton.com
Attention: Marc Morris, Principal Environment

1.3 Land Tenure

The Proposal is located within both the Yackabindie Pastoral Lease, held by NIW, and Mining Act 1978 tenure. The mining tenements relevant to the Proposal are listed in Table 1 and shown in Figure 2.

Table 1 Mt Keith Satellite Proposal Tenure

Tenement ID	Description	Area (ha)	Grant Date	Expiry/Sale Date	Tenement Holder
L36/206	Conveyor System, Powerline, Pipeline and Road (Mt Keith Satellite Proposal)	42.5	18/08/2011	17/08/2032	BHP BILLITON NICKEL WEST PTY LTD
M36/183	Six Mile Resource (Mt Keith Satellite Proposal)	835.5	26/07/1990	25/07/2032	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/184	Serp Hill Mineralisation & Five Creeks Prospect (Mt Keith Satellite Proposal)	886.45	26/07/1990	25/07/2032	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/185	Goliath North Resource & Sheba Prospect (Mt Keith Satellite Proposal)	668.5	26/07/1990	25/07/2032	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/246	Six Mile North Location, Betheno Mineralisation (Mt Keith Satellite Proposal)	757.6	13/10/1992	12/10/2034	BHP BILLITON NICKEL WEST PTY LTD
M36/285	Mt. Pascoe (Mt Keith Satellite Proposal)	858.85	4/02/1994	3/02/2036	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/286	Mt. Pascoe (Mt Keith Satellite Proposal)	839.05	4/02/1994	3/02/2036	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/288	Six Mile Well (Mt Keith Satellite Proposal)	521.85	4/02/1994	3/02/2036	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/399	Six Mile North Location - Gold Option Tenement (Mt Keith Satellite Proposal)	13.81	10/12/2008	9/12/2029	BHP BILLITON NICKEL WEST PTY LTD
M36/422	Wanjarri Excision Area (Mt Keith Satellite Proposal)	669.35	8/06/2015	7/06/2036	BHP BILLITON YAKABINDIE NICKEL PTY LTD
M36/658	Gold Option Tenement (Mt Keith Satellite Proposal)	864.7	31/07/2006	30/07/2027	BHP BILLITON NICKEL WEST PTY LTD
M36/677	Yakabindie Transport Corridor (Mt Keith Satellite Proposal)	18.58	22/02/2007	21/02/2028	BHP BILLITON NICKEL WEST PTY LTD
M53/217	Tailings Storage Facility	948.80	2/04/1992	1/04/2034	BHP BILLITON NICKEL WEST PTY LTD
M53/218	Includes a minor portion of the Mt Keith Airstrip	924.55	2/04/1992	1/04/2034	BHP BILLITON NICKEL WEST PTY LTD

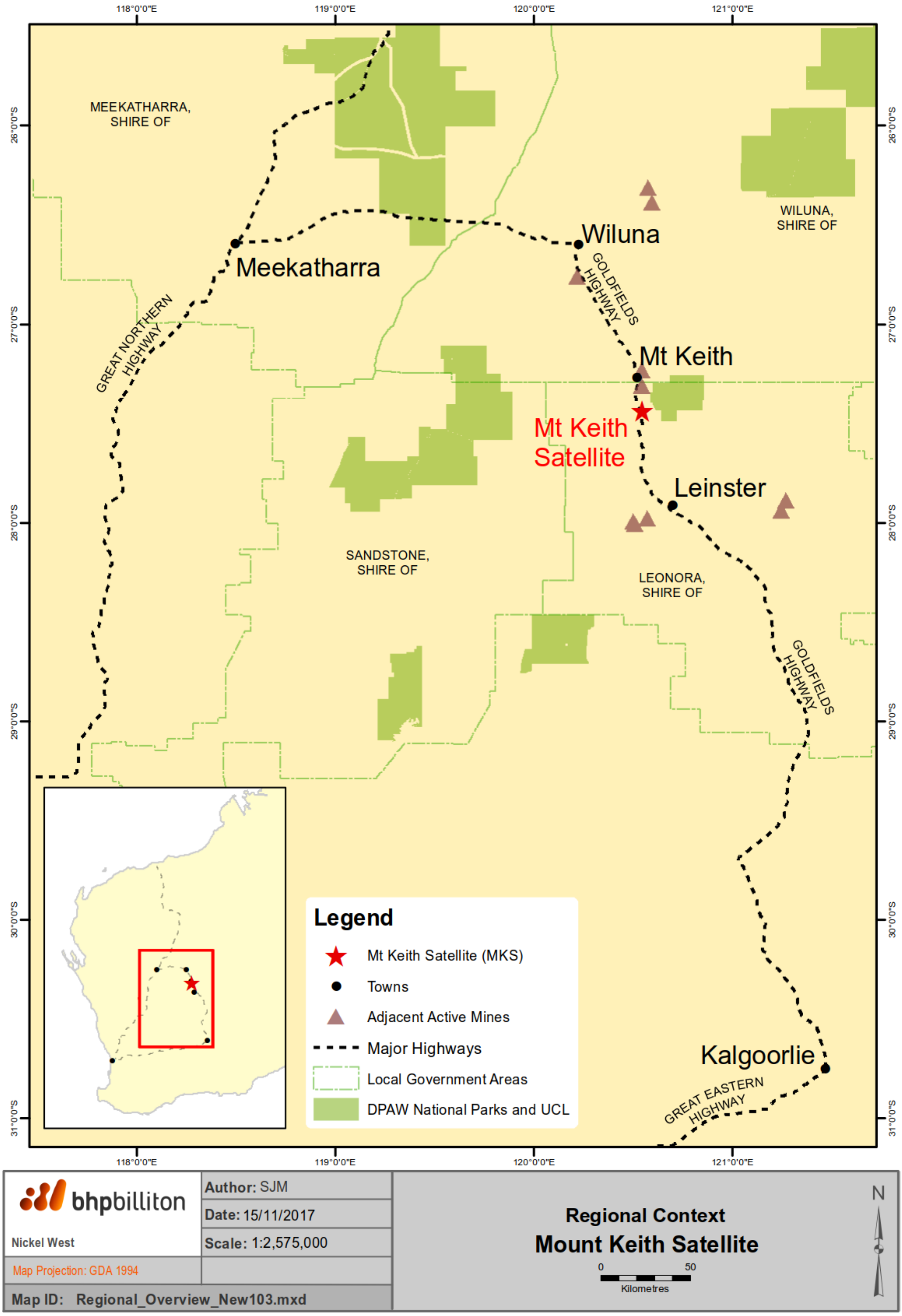

Figure 1 MKS Regional Context

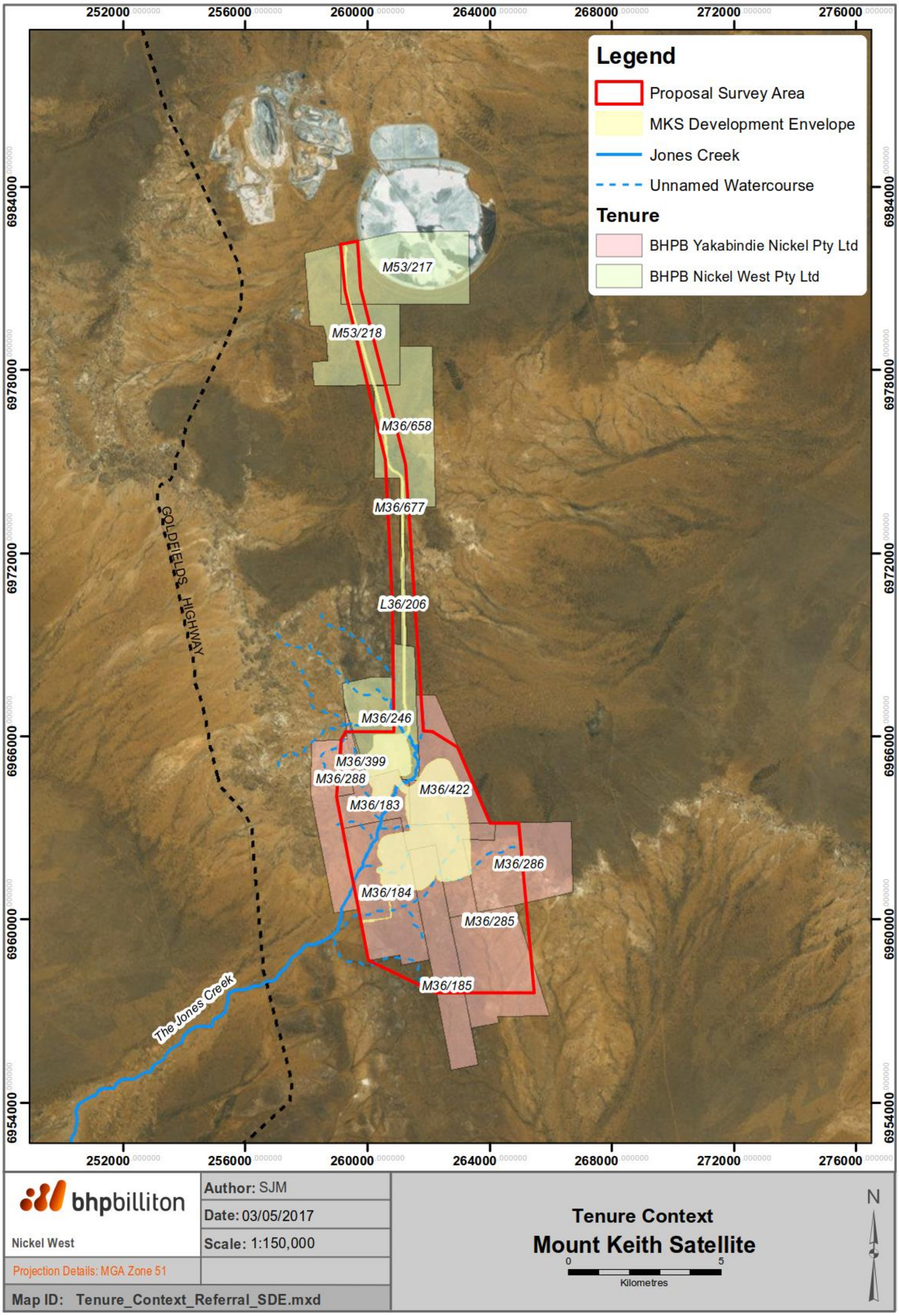

Figure 2 MKS Mining Tenure

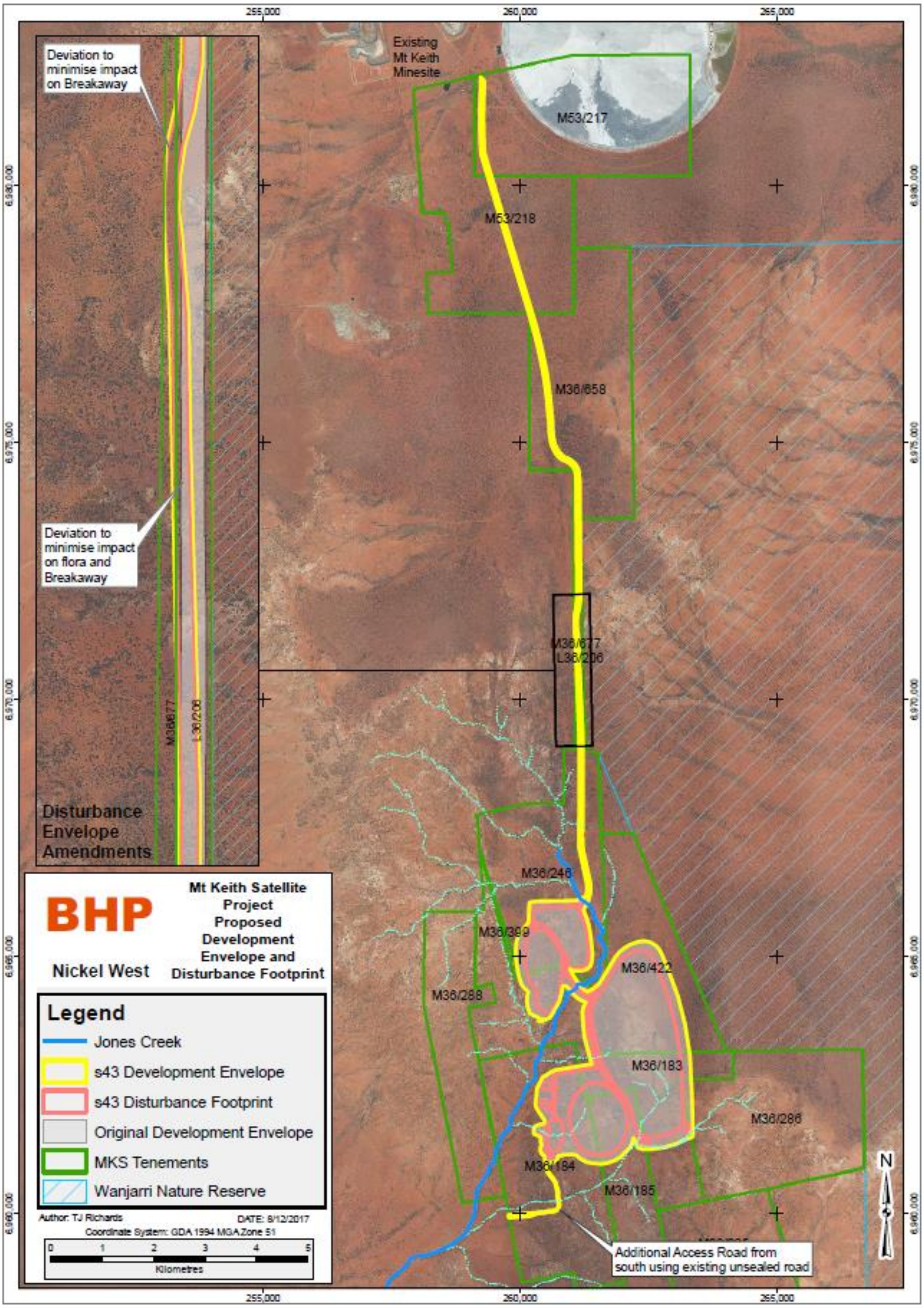

Figure 3 MKS Development Envelope and Disturbance Footprint

1.4 Environmental Impact Assessment Process

The key legislative requirements relating environmental impact assessment of the Proposal derive from the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) and the Western Australian EP Act. There are several other key WA environmental and heritage approvals required to implement the Proposal which are discussed in Section 1.6.

Commonwealth environmental assessment process

The EPBC Act provides for the protection of the environment, especially matters of national environmental significance. If a proposed development or other action ('proposed action') is likely to have a significant impact upon a protected matter then it must be referred for assessment under the EPBC Act (DSEWPC, 2012).

In the context of this Proposal, the relevant matter of national environmental significance (**MNES**) is "nationally threatened species and ecological communities", in particular the Night Parrot, Malleefowl, Black-footed Rock – wallaby. Under the EPBC Act the proposed action for consideration was the clearing of native vegetation "likely to impact on members of any listed threatened species, threatened environmental communities or their habitat".

The referral decision of the Department of the Environment and Energy (**DEE**) (15 September 2017) was that the proposed action is not a controlled action (Appendix A). No further assessment of protected matters is required under the EPBC Act for this Proposal.

State environmental assessment process

In 1990, the EPA assessed a proposal to mine nickel and process low-grade nickel sulphide in a similar location to the current Proposal within the Yakabindie Pastoral Lease. The 1990 proposal, referred to as the Yakabindie Nickel Project in Ministerial Statement 117, has not been implemented. The MKS Proposal is a substantially simplified and dissimilar proposal, as per the Referral supporting documentation.

The Proposal was referred to the Western Australian EPA under s 38 of the EP Act on 3 May 2017. On 19 July 2017, the EPA determined that the Proposal required an environmental assessment at Environmental Review – Environmental Review Document (**ERD**), with no public review period.

On 14 November 2017, the EPA issued an ESD (Appendix B) for the Proposal. The purpose of the ESD is to:

- provide proposal-specific guidelines on the preliminary key environmental factors that are to be addressed during the environmental review;
- identify the required work that needs to be carried out; and
- provide details on the timing of the environmental review.

This ERD documents NIW's assessment of the potential impacts of the Proposal with regards to the environmental factors as outlined in the ESD. The EIA will be conducted in accordance with various relevant EPA procedures, position statements and guidance documents, as detailed in Table 2 and the EIA sections of this document.

1.5 Policies and guidelines

The ESD lists a range of EPA and other policy and guidance relevant to this Proposal and required to be considered as part of the impact assessment process. A summary of how NIW has addressed the guidance relevant to the key environmental factors for the Proposal is provided in the impact assessment discussion for each factor.

A summary of general policy and guidance applicable to the Proposal is provided in Table 2.

Table 2 Summary of general policy and guidance applicable to the Proposal

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016).	Outlines the gazetted administrative procedures required of the EPA in administration and decision making under Part IV of the EP Act.	The proposal was referred to the EPA under s 38 of the EP Act on 3 May 2017 following pre-referral discussions with the EPA. A decision to assess the proposal pursuant to s 39 (1) of the EP Act was made on 19 July 2017, with level of assessment set at "Environmental review - Environment Review Document (s. 40(2) (b))*"*. The EPA prepared ESD was approved and issued to NIW on 14 November 2017.
Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2016).	Provides more detailed guidance on the processes and procedures for EIA of proposals under Part IV of the EP Act.	
Statement of Environmental Principles, Factors and Objectives (EPA, 2016).	Outlines environmental principles, factors and associated objectives which underpin the EIA process. The EPA uses environmental principles, factors and associated objectives as the basis of the EIA process and for assessing whether a proposal's impact on the environment is acceptable.	The ESD outlines the EPA's key preliminary environmental factors for the Proposal and work required by NIW to enable an appropriate level of EIA. The ERD documents the work completed by NIW to address the key and other environmental factors raised in the ESD.
Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA, 2018).	Provides guidance to proponents on the content and format of environmental management plans required as part of the Part IV assessment process of the EP Act.	Used as a guideline for the preparation of the Management Plans prepared as part of this Assessment (Appendices C, D and E).
Other Policy and Guidelines		
Guidelines for Preparing Mine Closure Plans (DMP and EPA, 2015).	Provides guidelines for the preparation of mine closure plans that meet the objectives and requirements for decommissioning and rehabilitation of both the Department of Mines, Industry Regulation and Safety (DMIRS, formerly DMP) and the EPA.	The guidelines have been used in the preparation of the preliminary Mine Closure Plan for this Proposal (Appendix E) as well as the existing Mt Keith mine (submitted to DMIRS on 25 November 2017).
WA Environmental Offsets Policy (The Government of Western Australia, 2011).	This policy provides a framework for the consistent application of environmental offsets to protect and conserve environmental and biodiversity values.	These documents have guided the consideration of whether or not offsets are required for the Proposal, where the offset is an offsite action(s) to address significant residual environmental impacts of the development. The impact assessment undertaken for this Proposal has considered that there are no significant residual impacts requiring the development of offsets
WA Environmental Offsets Guidelines (The Government of Western Australia, 2014).	These guidelines complement the WA Environmental Offsets Policy (Government of Western Australia, 2011) by clarifying the determination and application of environmental offsets in Western Australia. These guidelines expand on the offsets policy to ensure that the basis for decision-making on environmental offsets is understood by decision-makers.	
Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities, 2012).	This policy provides a framework for the consistent application of environmental offsets to protect and conserve environmental and biodiversity values. This policy relates to matters protected under the EPBC Act.	The Proposal was referred to the EPBC in August 2017, in relation to the proposed action (clearing of native vegetation) likely to impact on members of any listed threatened species, threatened environmental communities or their habitat (i.e. Night Parrot, Mallee fowl, Black-footed Rock – wallaby). The referral decision of the Department of the Environment and Energy (DEE) (September 2017) was that the proposed action is not a controlled action.

1.6 Other approvals and regulation

Section 45(1) of the EP Act requires the WA Minister for Environment to consult with other State decision-making authorities (**DMAs**) and, if possible, agree on whether the Proposal may be implemented and if so, what conditions and procedures should apply to implementation. DMAs are public authorities empowered by law or other statutory agreement to make a decision in respect of the Proposal. The DMAs identified for the Proposal in the ESD are listed in Table 3.

Table 3 Decision making authorities

Decision-making authority	Relevant Legislation
1. Minister for the Environment	*Wildlife Conservation Act 1950*
2. Minister for Water	*Rights in Water and Irrigation Act 1914*
3. Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972*
4. Executive Director Environment Division, Department Mines, Industry Regulation and Safety (DMIRS)	*Mining Act 1978*
5. Chief Dangerous Goods Officer, DMIRS	*Dangerous Goods Safety Act 2004*
6. State Mining Engineer, DMIRS	*Mines Safety and Inspection Act 1994*
7. Director General, Department of Water and Environmental Regulation	*Environmental Protection Act 1986* *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*

Other approvals relevant to this Proposal as required under the legislation listed in Table 3 are summarised in Table 4. For the purposes of the approvals listed in Table 4, the tenure applicable to the Proposal as described in Section 1.3, is granted mining leases issued under the *Mining Act 1978* (Mining Act).

Table 4 Other approvals and regulation

Proposal activities	Type of approval	Legislation regulating the activity
Clearing of native vegetation	Ministerial Statement	*Environmental Protection Act 1986* (Schedule 6 (2)(a))
	S18 Consent	*Aboriginal Heritage Act 1972*
Mine dewatering > 50 000 kL/yr.	EP Act licence amendment	Part V, *Environmental Protection Act 1986*
	Section 26D Licence to construct or alter a well Section 5C Licence to take water	*Rights in Water and Irrigation Act 1914*
Mining activities – including construction and operation of mine infrastructure including haul roads, pits, waste rock landforms, ancillary facilities (e.g. offices, fuel storage), decommissioning and rehabilitation	Mining Proposal and Mine Closure Plan	*Mining Act1978*
	Proposal Management Plan	*Mines Safety and Inspection Act 1994*
Fuel storage (>100 000L)	Dangerous Goods Storage Licence	*Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007*
Explosives storage and handling	Explosives storage licence	*Dangerous Goods Safety (Explosives) Regulations 2007*

2 The Proposal

2.1 Background

Existing Mt Keith Operations

Mt Keith Nickel Operation (**NMK**) is an open pit nickel mine located within the Shire of Wiluna, 720 kilometres North-East of Perth and 430 kilometres North of Kalgoorlie in Western Australia's North-Eastern Goldfields. The nearest population centres are Wiluna, 90 kilometres to the north, and Leinster, 80 kilometres to the south. NMK is wholly owned and operated by BHP Billiton Nickel West Pty Ltd (NiW), a subsidiary of BHP Billiton Pty Ltd. The mine commenced construction in 1993 and became operational in October 1994.

The mine operations area is located within two active pastoral stations, Mt Keith and Albion Downs, which are held by NiW and Albion Downs Pty Ltd, a wholly owned subsidiary of NiW. Nickel mining operations within the pastoral leases are conducted pursuant to mining tenements issued under the Mining Act.

NMK comprises an open cut mine, waste rock landforms, nickel sulphide concentrator, tailings storage facility and supporting infrastructure. The tailings facility is managed in accordance with Ministerial Statement 415, issued on 7 May 1996 (refer to Section 11.2).

Mining is undertaken at a rate of 30 to 50 Mtpa. Nickel concentrate is transported via road to Leinster for drying and blending. The final blend is transported from Leinster to Kalgoorlie Nickel Smelter via road and rail, for further processing.

Yakabindie Nickel Project

In February 1990, Dominion Mining Limited (**Dominion**) referred a proposal to the EPA for the development of the Yakabindie Nickel Proposal (**YNP**). YNP comprised open cut mining and processing of a low grade nickel sulphide orebody to produce approximately 6 million tonnes per annum (**Mtpa**) of ore and 25 Mtpa of waste rock. While the Proposal involves mining the same nickel orebody as the YNP the two projects are substantially different (Table 58).

The EPA recommended approval of the YNP with conditions in August 1990 and it was approved by the Minister for the Environment in December 1990 (Statement 117). Subsequent to Statement 117, the YNP has been subject to six reviews under s46 of the EP Act. These reviews related to changes to the conditions of the approval and extensions of the time limit of approval.

In 1994, Dominion entered into a joint venture with North Limited and completed a detailed feasibility study. Further work was conducted and changes of ownership occurred from 1995 to 2005 that resulted in Western Mining Corporation (**WMC**) taking ownership. In 2005, BHP conducted a takeover of WMC and commenced the mine planning and environmental investigations to update previous work. However, for commercial reasons, the YNP was not constructed and the Ministerial Statements issued for YNP are not applicable to this Proposal.

Mt Keith Satellite Project (the Proposal)

NiW intends to develop the Proposal, located approximately 15 to 20 km to the south of the existing Mt Keith operations. The Proposal involves the development of two mine pits (Six Mile Well and Goliath), a waste rock landform, associated support infrastructure and a transport corridor between the Proposal and NMK. The Proposal will provide nickel disseminated sulphide ore to NMK for processing via existing processing and tailings storage facilities. The existing workforce and associated infrastructure will be utilised for the Proposal.

The Proposal was referred to the Western Australian EPA under s 38 of the EP Act on 31 March 2017. Upon receipt of required further information, on 19 July 2017, the EPA determined that the Proposal required an environmental assessment at Environmental Review – Environmental Review Document (**ERD**), with no public review period.

Section 43A change to Proposal

On 6 October 2017, NIW submitted a request to the EPA to make changes to the Proposal, comprising

- increase of the Development Envelope from 1242ha to 1259 ha;
- increase of clearing footprint from 842 to 878 ha; and
- increase of water supply volume from 0.6 GL/a to 1.65 GL/a.

Table 5 describes the changes requested compared to the original Proposal submission.

Table 5 Section 43A Proposal Changes

Element	Original proposal	Changes to Proposal	Rationale for change
Transport Corridor	Clearing of approximately 51 ha of native vegetation within a Development Envelope of 1242 ha	Clearing of approximately 84 ha of native vegetation within a Development Envelope of 1259 ha	Changes to allow for minor alignment deviations and broadening of road footprint from 30m to up to 50m width, to facilitate construction (of road, temporary water storage, bunding drainage controls, laydown areas adjacent to road running surface), accommodate road design and creation of topsoil stockpiles adjacent to road for use in later rehabilitation. The deviations also reduce impacts to the edges of the breakaway landform which would require substantial modification through cut and fill and removal of cave and overhanging rock formations that could (although presently do not) provide habitat for black-footed rock wallaby. The deviations also reduce the impact to Priority flora species, which increase in abundance around the edges of the breakaway landform. The Development Envelope has been narrowed at this location.
Ancillary Support infrastructure	Clearing of approximately 134 ha of native vegetation within a Development Envelope of 1242ha	Clearing of approximately 137 ha of native vegetation within a Development Envelope of 1259 ha	An access road to the Proposal is required to be constructed linking the Proposal office with Miscellaneous Licence L36/110 and associated existing unsealed road. This feature, in combination with the existing unsealed road will provide safe access from the Goldfields Highway. The access road is to comprise a 10m wide unsealed road, primarily developed over existing exploration tracks (currently disturbed to a width of 5m) to minimise additional clearing. The second access is required to support mobilisation of machinery and equipment to site to commence the Proposal and for ongoing operations access for non-mining traffic, removing risk associated with interaction of heavy mining equipment and light vehicles.
Water Supply	Up to 0.6 GL per year from existing licensed borefields.	Up to 1.65 GL per year from existing licensed borefields.	A review of operational requirements for water determined additional supply is required to adequately provide for operational activities, including construction, dust suppression, hydro scaling and drill and blast operations. This water will be sourced from existing licensed borefields and reticulated via water carts and surface polyethylene piping.

The EPA issued a Notice of Decision to Consent to a Change to Proposal during Assessment on 6 November 2017 enabling assessment of the Proposal with these revised changes. The revised Development Envelope and

Disturbance Footprint resulting from this Section 43A process and to which the Proposal relates, is provided in Figure 3. The EPA issued an Environmental Scoping Document (ESD) on 14 November 2017. This assessment addresses the environmental factors and work items raised in the ESD (Appendix B).

2.2 Justification

Requirement for the Proposal and consideration of alternatives

As part of annual Life of Asset planning, NiW has identified additional ore resources required to ensure continuation of NMK operations. The current resources supplying Mt Keith are estimated to wind down towards the end of FY 2021 and additional supply is required prior to this time. NiW has already initiated mining approvals (through DMIRS) required for an additional cutback to the existing pit at NMK, which is anticipated to commence in 2018. However this will only provide resources to 2022. Not implementing the proposal would likely result in the closure of the NiW business as the business would no longer be economically viable.

The MKS orebody has previously been defined and estimated and preliminary mine planning undertaken. It is the next proven resource most readily available to supply ore to NMK out to 2040, through staged development of the transport corridor (FY2019) and pits commencing in FY2020 (pending approvals).

Optimisation of location and utilisation of existing infrastructure

The Proposal Development Footprint and Envelope have been substantially refined since the original Yakabindie proposal, not just due to reduction in scope but also in order to minimise environmental impact. In particular, the Proposal footprint has been designed to minimise impact to Jones Creek to two creek crossings and reroute haul road around breakaway landforms and heritage locations. The site is also constrained by tenement boundaries, and the adjacent Wanjarri Nature Reserve.

Where possible, existing fixed infrastructure of NMK will be used, in part to reduce the environmental Disturbance Footprint of the MKS operations and avoid duplication of infrastructure.

Evaluation of option not to undertake the Proposal

The Proposal will sustain the current level of NiW's nickel production in the Northern Goldfields, with the MKS production volume replacing existing deposits as they become depleted. If the Proposal were not to proceed, the impacts would include:

- loss of social, economic and employment opportunities in the Northern Goldfields (including Mt Keith, Leinster and Kalgoorlie) and Kwinana;
- loss in value of Western Australia and Australia's raw materials export;
- loss of royalty revenue to the Western Australian Government;
- non-utilisation of viable nickel and other metal deposits at Mt Keith; and
- decline in production from NiW's nickel mining and smelting operations.

NiW is the world's largest producer of nickel briquettes and powder, which are the preferred product for the lithium battery market. As recently presented to the Australian Nickel Conference, NiW is in an advantaged position to produce nickel sulphate product and is seeking to transition to become a globally significant battery material supplier (BHP, 2017).

2.3 Proposal description

Proposal Summary

The key components of the proposal are summarised in Table 6.

Table 6 Proposal Summary

Summary of the Proposal		
Proposal title	Mt Keith Satellite Project	
Proponent name	BHP Billiton Nickel West Pty Ltd	
Short description	The proposal is a satellite operation to the existing Mt Keith Mine and includes two open pits, a waste rock landform and a haul road corridor. Ancillary infrastructure that supports mining will be located at the satellite operation. The ore mined will be processed at the existing Mt Keith Mine located approximately 20 km north of the satellite operation. The proposal is located 80 km north of Leinster in the Shire of Leonora.	
Element	**Location**	**Proposed Extent**
Physical characteristics		
Mine pit (Goliath)	Figure 4	Clearing of approximately 212 ha of native vegetation within a Development Envelope of 1259 ha, mining in three stages within a 12 year timeframe.
Mine pit (Six Mile Well)		
Waste Rock Landform		Clearing of approximately 445 ha of native vegetation within a Development Envelope of 1259 ha.
Ancillary support infrastructure		Clearing of approximately 137 ha of native vegetation within a Development Envelope of 1259 ha.
Haul Road	Figure 3	Clearing of approximately 84 ha of native vegetation within a Development Envelope of 1259 ha.
Operational elements		
Pit dewatering	Figure 4	Water abstraction of up to 0.4 Gigalitres per year. Dewatering via bore/s and pit sumps.
Bore field supply	NA	Up to 1.65 Gigalitres per year from existing licensed fields.
Waste	Figure 4	Up to 800 Million tonnes of waste rock to be generated over the life of mine, to be stored in a Waste Rock Landform and used as backfill.

Construction

The southern access road will be developed to enable the mobilisation of machinery and equipment to site to commence clearing of vegetation and mining. This access road will be constructed over an existing unsealed road, widened from 5m to 10m and will link the Proposal to the Goldfields Highway, via Miscellaneous Licence L36/110.

Stripping of native vegetation and topsoil will then be required, to enable the initial development of Goliath and Six Mile Well pits, waste rock landform, ROM pad, and infrastructure area to commence. Topsoil will be stored in a combination of windrows and piles, primarily along the haul road corridor and also within the Disturbance Footprint of the mining and ancillary support infrastructure areas.

A nominal 30 m wide haul road will be developed for the transport ore to the existing Mt Keith mine. Topsoil and cleared vegetation stockpiles will be established alongside cleared operating areas to maintain local provenance of topsoil when undertaking rehabilitation. Disturbed construction areas, such as laydowns, not required for ongoing operations will be progressively rehabilitated. As the haul road passes through breakaway habitat that supports priority flora species, the development envelope has been narrowed to accommodate only the operational infrastructure. This has been done to minimise the potential direct disturbance from clearing at this location.

Stormwater diversion drains and capture dams will be constructed to minimise stormwater ingress to site and reduce the volume of dirty stormwater requiring treatment, as well as protecting the site from potential flooding during rainfall events (Section 9, Figure 62). Additional shallow drains to capture surface water around the waste rock landforms and other disturbed areas will be installed, which would then report to containment sumps.

Two creek crossings will be required to be constructed across Jones Creek to enable haul road access from the ROM pad to NMK and access between the pits and the waste rock landform. This will require a northern and southern crossing point. The crossings required the direct disturbance of approximately 1 ha of creek line vegetation, maintaining the 30m wide road through a crossing at or near surface. The construction of these crossings is discussed further in Section 8.

Ancillary support facilities will be established at this time and include offices, a fuel farm and dewatering facility for temporary storage of dewater (Figure 4).

Mining method

The proposal involves the mining of nickel sulphide ore through conventional open-cut mining methods, involving drill and blast and categorisation of blasted material into ore and waste rock. Ore will be moved to the ROM pad for stockpiling ahead of crushing, screening and processing at NMK. Waste rock will be moved to the waste rock landform. Technical studies have been undertaken to assess the likelihood of encountering potential acid forming (**PAF**) material and a broad risk assessment of acid and metalliferous drainage risk have been carried out (refer to Section 8 Hydrological Processes & Section 11.4 Mine Closure Planning).

Mine dewatering

The proposal will require in-pit and ex-pit (i.e. groundwater) abstraction to facilitate dry mining conditions. Groundwater abstraction (dewatering volumes and monitoring) will occur under existing *Rights in Water and Irrigation Act 1914* (**RIWI Act**) licences and Groundwater Well Licence Operating Strategy. During operations the abstracted water will be used to supply the Proposal's water requirements, supplemented by the existing NMK water supply, described in Section 8. The proposal will not generate surplus water.

Development Envelope

A 'Development Envelope' has been defined for this Proposal and is illustrated in Figure 3. This is the area in which NiW is seeking approval to implement the Proposal. The technical studies undertaken to inform the environmental impact assessment for this Proposal refer to this Development Envelope within their respective Study Areas. This area depicts the expected minimum clearing footprint, described as 'Disturbance Footprint' required to implement the Proposal. Where possible, potential impact of clearing has been calculated against both the development footprint and envelope representing actual and worst case scenarios.

The Development Envelope effectively provides a buffer zone and represents a credible 'worst case' implementation scenario. This assessment approach provides future flexibility for the location of mine components within the Proposal Development Envelope while also ensuring full extent of potential environmental impacts have been identified and assessed.

The mitigation hierarchy has been applied to the potential inherent impacts identified in the assessment to determine the residual impacts and likely significance thereof. This has involved the modification of the footprint of the Proposal to avoid or minimise direct and indirect impacts, in particular to known Priority flora locations and potential Black-footed Rock-wallaby habitat, as well as avoidance of heritage locations and minimising impact at Jones Creek crossings. The predicted Proposal impacts have been assessed and determined that the residual impacts of the final worst case implementation scenario can be managed.

A number of constraints and considerations have informed the proposed site layout. The haul road is constrained by a narrow section of tenure that positions the road adjacent the Wanjarri Nature Reserve and interception of the population of Priority Flora. The alignment has been narrowed and deviated the greatest extent possible within the constraints of tenure and topography. Other Proposal elements include the mine pits, waste rock landform and supporting mine infrastructure. The pits are fixed elements in that design is optimised to allow extraction of the ore resource while balancing geotechnical considerations and maintaining safety. The waste rock dump has been positioned east of the pits and the design extends its footprint outside of the PEC. The position and design of the WRL balances tenure constraints, proximity to Wanjarri Nature Reserve, closure requirements and distance to pits.

Supporting infrastructure is situated in the south western corner of the Proposal to provide a suitable security point to restrict access to the site. The specific elements, such as offices and fuel facilities, are moveable within the general location and have been positioned to avoid impacts to priority flora where possible. In order to move those elements outside of the PEC the Proposal would require additional disturbance footprint that would negate any benefit and result in additional impacts to Jones Creek in the form of an additional creek crossing by the access road. Additionally the Proposal elements have been presented and discussed with the Tjiwarl people and their feedback considered in the design. Changes in response to this consultation include the positioning of Jones creek crossings.

Mine Closure

Preliminary mine closure planning has been completed for the Proposal and resultant Mine Closure Plan (Appendix E) provides completion criteria and closure options, supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. Throughout the operations phase, iterations of the mine closure plan will progressively refine the closure options with available data, enabling detailed designs and completion criteria to be developed and progressive rehabilitation works to occur. As mining draws to a close, the detailed closure designs will be executed, and the site will move into the post-closure period of monitoring, reporting, completion and sign off. In all cases, the focus for the application of the relevant controls is on achieving the defined completion criteria and following the mitigation hierarchy of controls.

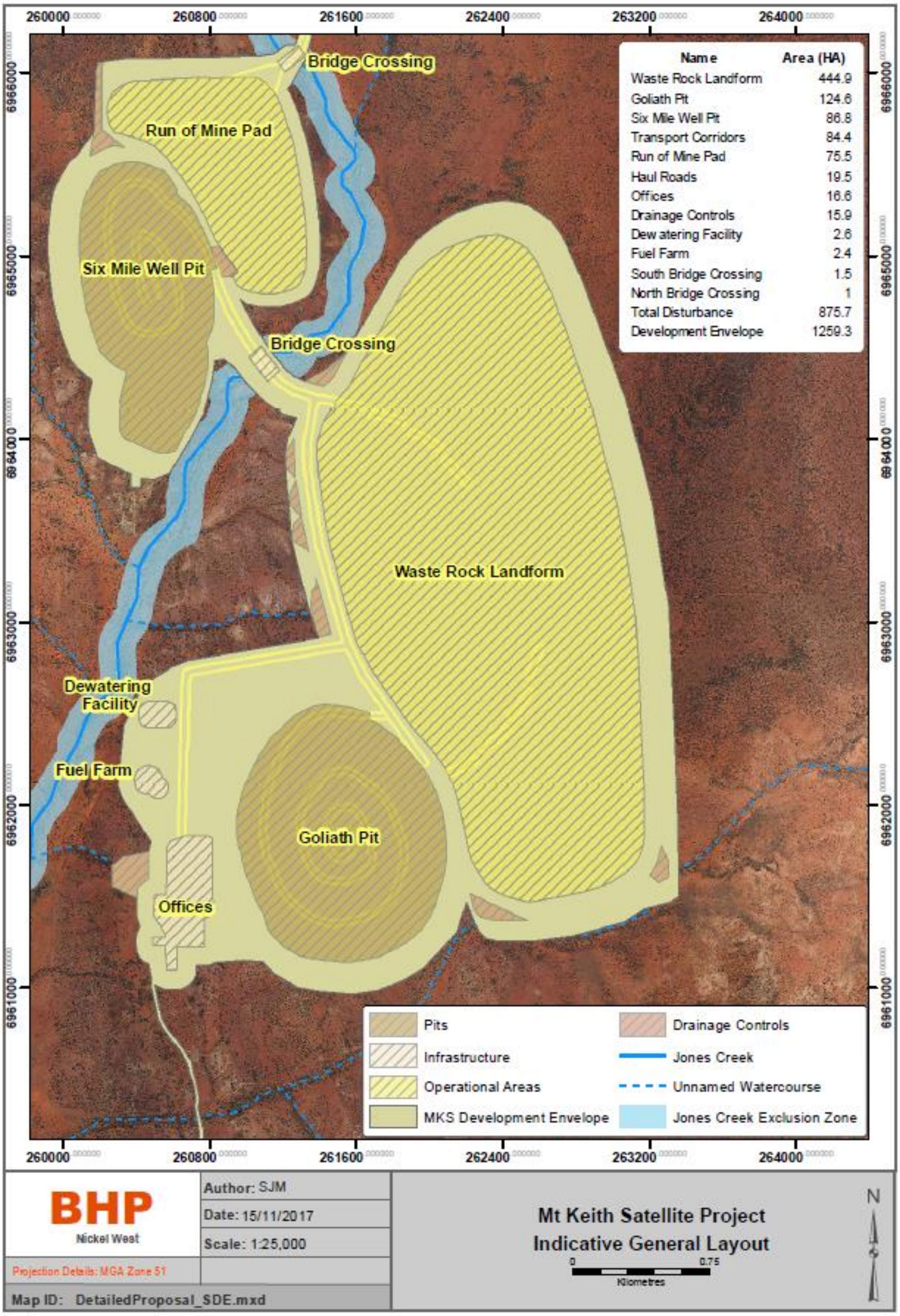

Figure 4 MKS Indicative General Layout

2.4 Local and regional context

Location

The Proposal is located in the north-eastern Goldfields of Western Australia, approximately 80 km north of Leinster in the Shire of Leonora and approximately 20 km south of the Mt Keith Mine 52 km, and 3 km east of the Goldfields Highway (Figure 1). The Proposal lies immediately adjacent to the western boundary of the Wanjarri Nature Reserve.

Geology

The Proposal lies in the north-eastern corner of the Archaean Yilgarn Block. The Eastern Goldfield Province is a typical Archaean granite-greenstone terrain characterised by large areas of granitic lithology and generally narrow, linear belts of greenstone (Griffin, 1990). Alluvial soils and sands overlay the granitic-greenstone units of the Yilgarn Craton. Underlying the soils in low areas is a red-brown siliceous hardpan (Curry et al., 1994). In the eastern half of the bioregion the soils are typically calcareous red earths, lithosols, duplex soil and clays and red sands, (Australian Natural Resources Atlas, 2007).

Western Botanical (2017) describe the Proposal as lying within the Keith – Kilkenny lineament geological anomaly that was interpreted and mapped from early reconnaissance data as a single fault line (GSWA, 1974 in AGSO Research Newsletter 20). This has been more recently described as not constituting a single simple continuous fault, but rather, is an artefact made up of separate, genetically unrelated segments, (AGSO Research Newsletter 20). The Yakabindie Greenstone belt is one of three distinct greenstone components of the Mt Keith – Perseverance fault, which is described by Liu *et al.* (2002) as follows:

“The Yakabindie greenstone belt comprises a layered sequence of the Kathleen Valley Gabbro overlain by the massive tholeiitic Mount Goode Basalt. The Agnew greenstone belt comprises a lower sequence of metamorphosed ultramafic, mafic, felsic volcanic, and sedimentary rocks, which is exposed in the Lawlers and Leinster Anticlines. The upper sequence, as exposed in the Mount White Syncline area, consists of metabasalt, metagabbro and metasedimentary rocks. Metamorphosed ultramafic, mafic, felsic volcanic and sedimentary rocks in the Perseverance area extend farther north to west of Mount Pasco. From Six Mile Well, ultramafic, sedimentary, and felsic volcanic/volcaniclastic rocks correlate with the greenstone sequences from Mount Keith to Wiluna. The Jones Creek Conglomerate represents a late clastic sequence and is restricted to a narrow, fault-bounded zone between the Yakabindie greenstone belt and granitoid in the west and the Mount Keith–Perseverance and Agnew greenstone belts to the east.”

Biogeographic Region

The Proposal Study Area (the Study Area) is located within the eastern portion of the Murchison Biogeographic Region and the East Murchison (MUR1) subregion. The MUR1 subregion covers an area of 7,847,996 ha, covering northern parts of the ‘Southern Cross’ and ‘Eastern Goldfields’ Terranes of the Yilgarn Craton (Cowan, 2001). This subregion is characterised by:

- internal drainage;
- extensive areas of elevated red desert sand plains with minimal dune development;
- salt lake systems associated with occluded Palaeodrainage system; and
- broad plains of red-brown soils and granitic breakaway complexes as well as red sand plains (Cowan, 2001).

The vegetation in this region is dominated by Mulga varieties (*Acacia aneura* sens. lat. And related taxa), shrublands / woodlands often rich in ephemeral species, Spinifex (*Triodia* spp.), hummock grasslands, Saltbush shrublands (*Atriplex* spp.) and Samphire (*Tecticornia* spp.) shrublands. Land use within MUR1 is predominantly pastoral and mining (often combined) (Cowan, 2001).

The region inclusive of the Study Area has been subject to extensive pastoralism, some road infrastructure development and the development of numerous mining operations. Overall, on a regional scale within the eastern Murchison biogeographic region, clearing of land by these activities is small and the land has not been extensively cleared.

Climate

The Murchison bioregion has an arid climate and rainfall can occur at any time of year. The average annual rainfall is approximately 210 mm and is variable throughout the region (Pringle *et al.,* 1994). Summers are hot and dry with infrequent, high intensity seasonal thunderstorms and occasional cyclonic events. Maximum temperatures across the region exceed 40°C during the summer months and winters are mild with cool nights (Bureau of Meteorology, 2017).

The Leinster Aero weather station (site number 012314) located approximately 77km to the south is the closest Bureau of Meteorology data collection site to the Study Area. The Proposal Area's climate is semi-arid with cool winters and hot summers. The seasonal range in mean daily minimum temperature is 5 to 23°C and in maximum temperature is 19 to 38°C. Wind strengths are generally moderate, averaging between 8 to 12 km/hr over most of the year. The prevailing wind direction is from the east to southeast over most of the year. Stronger westerly winds occur in spring, with September average afternoon strengths exceeding 40 km/hr on an average of 1 day per month. High temperatures and low humidity throughout much of the year produce an average pan evaporation of about 3,200 mm, and average evaporation exceeds average rainfall in all months of the year (MWES, 2017).

The long term average rainfall for the Mt Keith area is about 235 mm. Average monthly rainfall is reasonably consistent from December to July (25 to 35 mm) and from August to November (10 to 20 mm). The average number of rain days per year (> 1 mm) is about 32. High intensity rains occur more commonly in summer, caused by localised thunderstorm activity or much larger weather systems associated with cyclones and tropical lows, however high intensity rain can also occur in association with winter weather patterns. Low rainfall intensity and low rainfall totals occur most consistently in the months of September to November (MWES, 2017).

Wanjarri Nature Reserve

The Wanjarri Nature Reserve is the only reserve in the northern part of the eastern goldfields and is listed by the Australian Heritage Commission on the Register of the National Estate. The arid zone conservation reserve was formerly a small pastoral lease of 53 000 ha until 1971 when it was destocked and became an A Class Nature Reserve.

The landscape of the Reserve is dominated by extensive undulating sandplains with sand dunes, with breakaways and low granite hills numerous within the Reserve. The key vegetation component is spinifex grasslands with mulga complexes occurring mainly in the western third of the Reserve. The Reserve has high conservation values within the landforms represented (although not all of the regional landforms occur within it) and is an important area for research into the biology and habitat requirements of a range of animals, particularly birds. It is recognised that the value for nature conservation is limited by the pastoral and mining activities on land surrounding the Reserve (CALM, 1996).

3 Stakeholder Engagement

3.1 Key stakeholders

Key stakeholders identified for this proposal include:

- Department of Biodiversity, Conservation and Attractions (DBCA)
- Department of Mines, Industry Regulation and Safety (DMIRS)
- Department of Planning, Lands and Heritage (DPLH)
- Department of Water and Environmental Regulation (DWER)
- Environmental Protection Authority (EPA)
- Shires of Wiluna and Leonora
- Tjiwarl Native Title Holders (Tjiwarl)

3.2 Stakeholder engagement process

NiW aims to consult with all identified stakeholders throughout and beyond the approvals process. The objectives for this consultation are as follows:

- engage appropriately with stakeholders to ensure that all stakeholders understand the potential aspects and benefits of the development of the Proposal and the approvals required to successfully develop the Proposal;
- ensure that stakeholders understand that the approvals being sought are for the development of a satellite deposit to sustain the existing Mt Keith operation; and
- communicate with stakeholders in a clear and timely manner, consider the interests of and impacts on our stakeholders.

Consultation commenced with pre-referral discussion and is continuing as the approvals process is underway. Post referral consultation will be vital to ensure ongoing expectations are met with various stakeholders throughout the Proposal implementation and closure phases.

3.3 Stakeholder consultation

A summary of the stakeholder consultation is provided in Table 7.

Table 7 MKS Stakeholder Engagement

Stakeholder	Date	Topic/Issue	Proponent Response/Outcome
DBCA	21/10/2016	MKS Proposal Technical discussion - all aspects. DBCA (then Parks and Wildlife) indicated there was nothing related to the Proposal that would cause them concern at this time. The black flanked wallaby has significant habitat in this area and so Parks and Wildlife do not consider this an issue. Parks and Wildlife suggested that NiW follow up regarding Idiosoma sp. as the taxonomy has recently been reviewed.	NiW followed up regarding Idiosoma sp. as the taxonomy has recently been reviewed, WA Museum has confirmed that the species identified in Wanjarri and the Proposal area are not threatened. Parks and Wildlife have indicated that further consultation can wait until planned flora and vegetation assessments have been completed or referral has been submitted.
EPA	27/10/2016	WAIO session introducing NiW and requesting a pre-scoping session. EPA indicated which officers would work with NiW for the assessment process.	Follow up with NiW team member on the pre-scoping session.
DBCA	3/11/2016	Wanjarri Alternative access discussion. DBCA (Parks and Wildlife) indicated that the previous agreement signed in 2007 outlines the requirements NiW must adhere to and is looking for this signed version. Discussed proponent of the Gas Pipeline to access the pipeline corridor.	NiW to follow up regarding access. Access assessment trip is planned for March 2017 – NiW representatives will attend to assist with access assessment. Following subsequent communication in 2018, this trip now planned for August 2018.
EPA	27/11/2016	Pre-scoping session. Proposal scope discussed in detail.	-
EPA	28/12/2016	Pre-scoping session.	-
EPA	14/02/2017	Pre-referral session.	Submit s 38 referral in March 2017.
EPA	20/02/2017	Discussion and presentation regarding stygofauna to date and planned sampling program.	Send presentation to EPA. Submit a referral in March. Feedback on the proposed sampling program will be delivered in the scoping document phase of the approval. Meet again after round 1 sampling reporting is completed.
Shire of Wiluna	02/03/2017	Initial consultation regarding the Proposal was raised as part of ongoing stakeholder engagement activities with the Shire of Wiluna. A number of issues were discussed including the Shire being supportive of the Proposal as a potential income within the Shire. Environmental assessments completed were presented and updates requested by the Shire at future sessions.	NiW will keep the Shire updated as required. Further communication from NiW will occur in 2018 to provide an update to both the Shire of Wiluna and Leonora regarding the status of the proposal.
DMIRS	07/03/2017	Initial consultation and discussion regarding timing for approvals, closure plans requirements and other detail. DMIRS (then DMP) indicated that they will require a closure plan for the Proposal with the Mining Proposal.	DMIRS indicated that further consultation is not required until preparation to submit Mining Proposal application is scheduled.
JTSI	10/05/2017	Initial scoping discussion regarding MKS Proposal. JTSI (formerly DSD) acknowledged the Proposal outcomes for Nickel West and requested that Nickel West update them further as required.	Nickel West will keep JTSI updated as required.
DBCA	11/06/2017	Follow up consultation with DBCA regarding alternative access agreement and status of agreement between both parties.	NiW to meet with DBCA in 2018 to finalise necessary actions required under the agreement for management of the access road and implementation of signage ahead of mining activities commencing.
DEE	21/06/2017	Introduction of Proposal, fauna survey status and potential impacts to EPBC Act listed fauna. DEE provided overview of potential assessment pathways.	DEE recommended referral of the Proposal. Nickel West subsequently referred the Proposal which was determined Not a Controlled Action by DEE.
EPA	5/07/2017	Update on fauna survey status and outcomes and DEE engagement regarding Night Parrot.	Nickel West to confirm Proposals referral to DEE.
Tjiwarl People	25/07/2017	Formal briefing on MKS proposal with Tjiwarl AC directors.	Commitment to continuing discussions and updates.

Stakeholder	Date	Topic/Issue	Proponent Response/Outcome
EPA	11/10/2017	Meeting between EPA and NiW to discuss proposed Section 43A changes.	Additional mapping details provided to EPA and draft ESD provided to NiW. ESD finalised 14 November 2017.
Tjiwarl People	4/09/2017	Community meeting where information on the Proposal was provided.	-
DMIRS	19/09/2017	Proposal approvals process and timing.	Maintain consultation
Tjiwarl People	11/10/2017	NiW consultation on the Proposal with Tjiwarl AC directors.	On-going discussions and plan for site visit.
Tjiwarl People	6-7/11/2017	NiW consultation on the Proposal with Tjiwarl AC directors, site visit and Community meeting.	On-going discussions and information updates.
Tjiwarl People	27-28/11/2017	NiW consultation on the Proposal with Tjiwarl AC directors.	On-going discussions and information updates.
DPLH	8/12/2017	Briefing on Proposal	DPLH requested further information regarding an s 18 condition. NiW provided the information.
Tjiwarl People	13-14/12/2017	NiW consultation on the Proposal with Tjiwarl AC directors including a detailed environmental impact briefing.	On-going discussions and information updates.
Tjiwarl People Directors	7-8/02/2018	NiW consultation on the proposal with Tjiwarl AC	On-going discussions and information updates
Tjiwarl People Directors	26-27/02/2018	NiW consultation on the proposal with Tjiwarl AC	On-going discussions and information updates
Tjiwarl People	27/03/2008	NiW consultation with Tjiwarl on heritage aspects of Proposal	Continuing work on management of any heritage impacts
EPA	21/04/2018	Consultation on offset chapter of ERD and management plans required under scoping document	Revised ERD and management plans to be prepared and discussed further.
EPA	20/04/2018	Consultation on management plans required under scoping document	Revised management plans to be submitted.
EPA	20/06/2018	Consultation on EIA schedule	NiW to engage with other agencies to resolve any concerns regarding Proposal
DMIRS	27/06/2018	Update on project status	On-going discussions and information updates
EPA	28/06/2018	Consultation on EIA schedule	Maintain consultation
EPA	04/07/2018	Consultation on ERD document review and schedule	Final revision of ERD and associated management plans in accordance with document review action items. Site visit with EPA to be arranged for August.

4 Environmental Principles and Factors

The EPA uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal impact on the environment is acceptable. Section 4A EP Act establishes the object and principles of the Act, which are described in Table 8 along with NiW's consideration of these principles in its assessment of the potential impacts of this Proposal.

Table 8 Environmental Protection Act 1986 Principles

Principle	Consideration
1. **The precautionary principle** Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by: a. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b. an assessment of the risk-weighted consequences of various options	Biological surveys, EIAs and application of the mitigation hierarchy have been carried out in line with the precautionary principle. Specialist technical impact assessments have been carried out to assess potential impacts and propose potential management strategies. Where the potential for serious or irreversible damage was identified, mitigation measures, including avoiding impacts where practical, have been applied and a precautionary approach taken when residual risk is uncertain
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Regional datasets have been used to assess impacts to health, diversity and productivity of the environment surrounding the Proposal. Mine closure technical studies and modelling have been carried out to inform this impact assessment and a Mine Closure Plan developed to ensure the Proposal is closed in a manner to ensure that the health, diversity and productivity of the environment is maintained for future generations. Where, residual impacts have been identified mitigation measures are proposed.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Baseline biological surveys have been completed. Technical impact assessments have been completed to determine potential impacts to biological diversity. Management measures, including adaptive management, have been proposed to mitigate biodiversity and ecological impacts associated with implementation of the Proposal. Management measures and closure objectives are developed to ensure conservation of biological diversity.
4. Principles relating to improved valuation, pricing and incentive mechanisms a. Environmental factors should be included in the valuation of assets and services. b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	Environmental factors have been considered throughout the development of this Proposal. Specialist technical studies have been carried out to optimise the mine design so as to minimise environmental impacts and to inform detailed environmental impact evaluations and management measures that aim to minimise pollution and waste.

Principle	Consideration
5. The principle of waste minimisation. All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Standard waste management measures are a key element for the implementation of this Proposal. It is standard practice for the Proponent to apply the waste management hierarchy (i.e. avoid, reduce, reuse, recycle, recover, treat, contain and dispose) to all sites, and this will be the case in relation to this Proposal.

The preliminary key environmental factors identified for this environmental review, and the relevant sections in which these factors are assessed, are as follows:

- Flora and vegetation Section 5
- Terrestrial Fauna Section 6
- Subterranean Fauna Section 7
- Hydrological Processes Section 8
- Inland Waters Environmental Quality Section 9
- Social Surroundings Section 10

5 Flora and Vegetation

5.1 EPA objective, policies and guidance

The EPA's objective for flora and vegetation is:

> "To protect flora and vegetation so that biological diversity and ecological integrity are maintained".

The EPA defines ecological integrity as *"the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements".*

The policy and guidance documents considered in the environmental impact assessment (EIA) for this factor are listed in Table 9. The ERD is consistent with these guidelines.

Table 9 Policy and guidance relevant to Flora and Vegetation

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Flora and Vegetation (EPA, 2016).	Outlines how the EPA considers flora and vegetation in the EIA process, including how this factor links with other environmental factors.	The ERD describes the flora and vegetation of the Study Area as assessed via numerous surveys, including 2016-17 targeted survey work (Appendix F). The impacts of clearing on vegetation communities, individual populations of Priority species and the Violet Ranges Priority Ecological Community (PEC) have been assessed at both local and regional level. An assessment has been made against the Clearing Principles specified in the Act, determining that the clearing is not at variance with these principles. The ERD demonstrates that clearing impacts will be of minor significance at local and regional scale and can be adequately managed through appropriate mitigation measures.
Other Policy and Guidelines		
Technical Guidance – Flora and Vegetation Surveys for Environmental Impacts Assessment (EPA, 2016).	Provides detailed guidance on survey methods for botanical surveys undertaken in Western Australia. It was developed by the EPA to ensure that data collected for EIA are of an appropriate standard.	The flora and vegetation survey report undertaken by Western Botanical was prepared in accordance with EPA Guidance Statement 51 and the 2016 Technical Guidance on Flora and Vegetation surveys.
WA Environmental Offsets Policy (The Government of Western Australia, 2011).	This policy provides a framework for the consistent application of environmental offsets to protect and conserve environmental and biodiversity values.	These documents have guided the consideration of whether or not offsets are required for the Proposal, where the offset is an offsite action(s) to address significant residual environmental impacts of the development. The impact assessment undertaken for this Proposal has considered that there are no significant residual impacts requiring the development of offsets
WA Environmental Offsets Guidelines (The Government of Western Australia, 2014).	These guidelines complement the WA Environmental Offsets Policy (Government of Western Australia, 2011) by clarifying the determination and application of environmental offsets in Western Australia. These guidelines expand on the offsets policy to ensure that the basis for decision-making on environmental offsets is understood by decision-makers.	

5.2 Receiving Environment

Study Area and survey efforts

The Study Area (Figure 5) has been subject to extensive field surveying since 1990, including desktop, reconnaissance and detailed surveys and targeted work for *Acacia* species, as described in Table 10. Western Botanical's (2017) most recent survey, covered approximately 5,422 ha encompassing the Study Area; comprised of 878 ha of Disturbance Footprint within 1259 ha of Development Envelope.

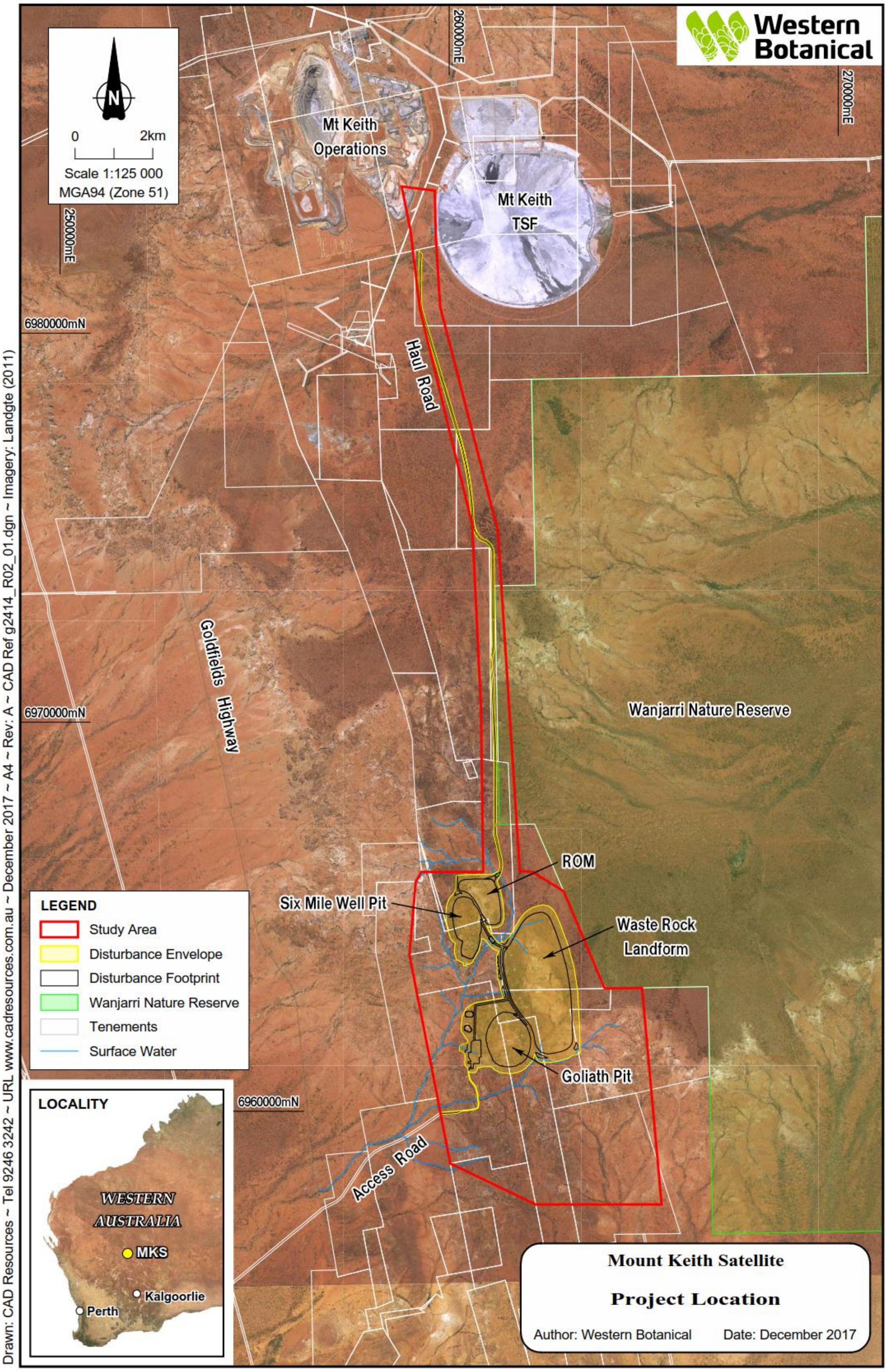

Figure 5 Proposal Study Area

Table 10 MKS Proposal Flora and Vegetation Assessments

Author	Title	Date	Scope
Western Botanical	Flora and Vegetation Assessment of the Mt Keith Satellite Operations Study Area	October 2017	Review and update of the previous baseline flora and vegetation report (2012) following a revision of the area surveyed including supplementary field works conducted during November-December 2016. Area survey covers 5,422 ha. The initial March 2017 report updated to include the results of further targeted surveys, undertaken in August to October 2017, and revised Proposal footprint.
Western Botanical	Flora and Vegetation Assessment, Yakabindie Nickel Proposal	September 2016	A review and update of all data relating to flora and vegetation, including review of previous reports relating to the Mount Keith Satellite Operations Study Area inclusive of the Six Mile and Goliath pits and related infrastructure and produce an updated report meeting the requirements of EPA Guidance Statement 51 and Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment.
Western Botanical	Baseline review and statistical analysis of the flora and vegetation of the (previously proposed) NDS1 mine and corridor Study Area.	2012	A review and synthesis of previous works and addition of quadrat-based vegetation assessment and analysis, to meet the criteria of a Level 2 Survey. Includes Six-mile and Goliath orebody areas, waste rock storage area, and associated transport corridor based on additional field works implemented in 2011.
Western Botanical	Assessment of flora and vegetation, Yakabindie Proposal (draft report)	2009	Level 1 assessment commissioned for the purposes of applying for a Native Vegetation Clearing Permit (NVCP) for the (previously proposed) YNP.
Western Botanical	Flora, vegetation and habitats of the Yakabindie tenements 2004-2005	2006a	Level 1 assessment inclusive of the initial review of flora, vegetation, and conservation values of Yakabindie tenements and surrounding local areas. This represents the most comprehensive and extensive works conducted at the Mt Keith Study Area inclusive of vegetation mapping, habitat descriptions and species profiles.
Western Botanical	Review of flora, vegetation, landscapes and conservation values of the Six-mile and Sir Samuel blocks, Wanjarri Nature Reserve and Yakabindie Station	2006b	Level 1 assessment of a section of Wanjarri Nature Reserve and a section of Sir Samuel Block, in preparation for a land swap to facilitate mining at Yakabindie Nickel Proposal.
Landcare Services	Review of *Hemigenia exilis* (S. Moore)	2001	Combined all data including WMC, Anaconda Nickel and CALM sources to review the status of *Hemigenia exilis* (DRF) resulting total of 46,005 plants from 66 populations and reduction to Priority 4 status.
Landcare Services	A review of *Hemigenia exilis* (S. Moore) populations at The Mt Keith Operation and within the north-eastern Goldfields	1996	Targeted survey and review of Hemigenia exilis local and regional populations, incorporating data supplied by Anaconda Nickel.
Ecologia	Yakabindie Nickel Proposal: *Hemigenia exilis* survey and management plan	1996	Targeted survey and management of *Hemigenia exilis*, previously ranked as Declared Rare Flora, at the Yakabindie Nickel Proposal.
Ecologia	Yakabindie nickel mine Proposal, Six Mile Well – Mt Pasco blocks: environmental assessment	1995	Unknown.
Mattiske Consulting Pty Ltd	Summary of *Hybanthus floribundus* subsp. *chloroxanthus* E.M. Benn. (Priority 3) Populations, Yakabindie	September 2011	Confirmation of the identification of populations previously recorded in the Proposal area and abundance of the populations of *Hybanthus floribundus* subsp. *chloroxanthus* (Priority 3) outside immediate impact areas.
Ecologia Ecological Consultants	*Yakabindie Nickel Mine Proposal Consultative Environmental Review: Flora and Fauna Survey*	March 1990	Documentation of existing biota, delineation of the main ecological units, map the area and integration of previously published and unpublished vegetation information.

Western Botanical's 2017 report (Appendix F) was prepared to meet the requirements for Impact Assessment in accordance with the EPA's *Guidance Statement 51* and recent (2016) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*. The overall survey effort included a desktop assessment, three EIA field surveys in November and December 2016 (total of 86 person days) and three field surveys over July, August and September 2017 for targeted *Hibbertia* and *Acacia* studies.

Pre-European vegetation

Five of Beard *et al.* (2013) Pre-European Vegetation units are present within the Study Area (Table 11, Figure 6):

- Low Mulga Woodlands (Wiluna 18),
- Mulga Shrublands (Wiluna 39),

- Hummock Hard Spinifex Grasslands with emergent Mulga and Eucalyptus kingsmillii (Wiluna 107), and
- Mulga and Acacia quadrimarginea Shrublands (Wiluna 202). These are impacted to minor degrees by the current proposal with proportional impacts well below 1%.

The mapping is conducted at a high level and the proportional impacts of the Proposal on these are negligible in both a local and regional sense (Western Botanical, 2017).

Table 11 Pre-European vegetation systems of the Proposal Study Area

Name	Description	Total Area in Western Australia (ha)	Proposal Study Area (ha)	Proposal development envelope area (ha)	% within Proposal development envelope ha
WILUNA_18	Low woodland; Mulga (*Acacia aneura sens. lat.*)	4,313,796	2,535.66	386.23	0.0090
WILUNA_39	Shrublands; Mulga scrub	427,183	2,586.17	854.52	0.2000
WILUNA_107	Hummock grasslands, shrub steppe; mulga and *Eucalyptus kingsmillii* over Hard Spinifex	2,740,885	148.83	18.25	0.0007
WILUNA_202	Shrublands; Mulga & *Acacia quadrimarginea* scrub	88,114	151.43	0.00	0.0000

Land systems

Fourteen Land Systems are present within the Study Area and are described in Table 12, with their representation shown in Figure 7. These land systems are generally well represented in the broader north-eastern Goldfields region and specifically within the Eastern Murchison (MUR1) biogeographic region. Those Land Systems with the greatest representation within the Study Area are the low ironstone (limonitic duricrust) hills of the Bevon Land System (1785.88 ha), the Archaean granite breakaways and associated foot slopes of the Sherwood Land System (1089.40 ha), and the extensive orange sandplains of the Bullimore Land System (542.03 ha). These represent 0.8221%, 0.1325% and 0.0207% of their respective regional areas of occupancy in the north-eastern Goldfields.

The gently undulating stony plains and low rises with quartz mantles on granite supporting acacia-eremophila shrublands of the Windarra System (465.74 ha), the hardpan plains with ironstone gravel mantles of the Jundee Land System (341.95 ha), and the gravely hardpan plains of the Tiger Land System (335.25 ha), also occupy relatively large areas within the Study Area. This represents 0.2116%, 0.8636% and 0.3038%, of their respective regional areas of occupancy in the north-eastern Goldfields (Table 12).

Eight Land Systems are represented by smaller areas, from 10.76 ha of large creeks with extensive distributary fans supporting mulga and chenopod shrubland of the Wilson Land System to 235.86 ha within the gently undulating gravelly plains on greenstone, laterite and hardpan of the Violet Land System. Each of these represent less than 0.2% of their respective regional area of occupancy in the north-eastern Goldfields (Table 12).

Land systems mapping is based on broadly mapped vegetation, soils and underlying geology, but does not take into account cumulative impacts in the region.

Table 12 Land systems of the Study Area

Name	Description	Study Area (ha)	Regional total area (ha)	Proposal Development Envelope ha (%)
Wilson	Large creeks with extensive distributary fans, supporting mulga and chenopod shrublands.	10.76	48,423.70	0.00 (0.00%)
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.	61.97	2,013,881.20	3.30 (0.0006%)
Wyarri	Granite domes, hills and tor fields with gritty surfaced fringing plains supporting mulga and granite wattle shrublands.	62.72	88,823.10	0.00 (0.00%)
Ararak	Broad plains with mantles of ironstone gravel supporting mulga shrublands with wanderrie grasses.	64.11	208,031.70	8.33 (0.0044%)
Sunrise	Stony plains supporting mulga shrublands.	69.22	36,218.00	1.66 (0.0046%)
Monk	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	155.26	998,651.60	4.23 (0.0078%)
Nubev	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	201.95	152,701.90	130.98 (0.0895%)
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.	235.86	549,845.00	45.73 (0.0139%)
Tiger	Gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses.	335.25	109,873.50	140.34 (0.1272%)
Jundee	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	341.95	666,389.20	32.06 (0.0078%)
Windarra	Gently undulating stony plains and low rises with quartz mantles on granite, supporting acacia-eremophila shrublands.	465.74	230,050.20	214.89 (0.0976%)
Bullimore	Gently undulating sandplain with occasional linear dunes and stripped surfaces supporting spinifex grasslands with mallees and Acacia shrubs.	542.03	4,766,266.40	112.87 (0.0043%)
Sherwood	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting mulga shrublands and minor halophytic shrublands.	1,089.40	1,579,987.80	3.86 (0.0005%)
Bevon	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	1,785.88	239,333.90	559.53 (0.2575%)

Landform systems

Landform Systems, rather than the Land Systems described above, have been the preferred unit for grouping the vegetation recognised in the 2010 and 2011 vegetation surveys for statistical analysis within the Study Area. These reflect local changes in underlying geology, landform and soils, which influence vegetation.

Six Landform Systems (Drainage Line and Hardpan with Sheet Flow, Low Rises on Granite, Low Rises on Calcrete, Low Rises on Basalt, Sandplain, and the Lateritic Duricrust) were recognised and defined within the

Study Area, are considered to be widespread within the north-eastern Goldfields, as are many of the Vegetation Communities they support (Western Botanical, 2017).

Three Landform Systems with accompanying Habitat Units are less widely distributed in the region:

The Lateritic Duricrust Landform System is specifically associated with the Bevon Land System within the Perseverance Greenstone Belt.

The Low Rises on Granite Landform System is associated with the Sherwood Land System which is widespread but of limited area and occurring in disjunct occurrences in the Murchison biogeographic region.

Low Rises on Basalt Landform System is associated with the Basalt, mixed Acacia species Shrubland Complex (BaMAS) vegetation complex mapped within the Study Area. Low Rises on Basalt landform system extends further southwards from the Study Area within the Perseverance Greenstone Belt and more broadly within the eastern Murchison biogeographic region.

Vegetation communities associated with the Lateritic Duricrust Landform System include the Stony Ironstone Mulga Shrublands (SIMS) site type of Pringle et al (1994), the Stony Ironstone Low Shrublands (SILS), and the Stony Senna Shrublands (SSS) communities. The SILS community often supports species with conservation significance The SIMS and SILS communities may also support populations of *Eremophila* sp. Leinster (R.J. Cranfield 6767), a species of interest. The Basalt, mixed Acacia species Shrubland Complex (BaMAS) sits within the Bevon Land System and supports the newly recognised species *Acacia* sp. East Murchison Basalt (G. Cockerton 38064), a species of interest.

The Breakaway Shrubland (BRX) community associated with the Low Rises on Granite Landform System is a variable community that supports a range of species with conservation significance. These include *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771) P2, *Sida picklesiana* Priority 3 (P3), and *Verticordia jamiesonii* P3. Some areas of SILS community may also be found within this landform system and represent areas where the lateritic duricrust has been in close contact with the underlying granite plateaux.

The *Eucalyptus gypsophila – Eremophila pantonii* Woodland (EGPW) community occurs on eroded carbonate influenced soils with a slight ironstone and quartz pebbly mantle and occupies an area of 15.08 hectares within the Study Area. This is a discrete community within the region and occurs to the north, east and southeast of the Six Mile Well orebody. The EGPW community is not known to be widely distributed and occurrences are discrete and relatively small in area where it occurs. It is known from between the northern boundary of the Proposal and the existing NMK, west of the Proposal transport corridor. West of the proposed haul road alignment and outside the Study Area, the EGPW community as mapped supports the P3 species *Cratystylis centralis*.

The Breakaway Shrublands (BRX) vegetation community, associated with the Archaean granite breakaways of the Sherwood Land System, is highly variable in species composition and occurs in disjunct distributions across the region. It is known to support a wide range of Priority species and the new species *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771). The Proposal does not impact on significant areas of the Breakaway Shrublands vegetation community in relation to its local or regional occurrence although the proposed haul road does impact on the known population of *Hibbertia* sp. Sherwood Breakaways (R.J. Cranfield 6771).

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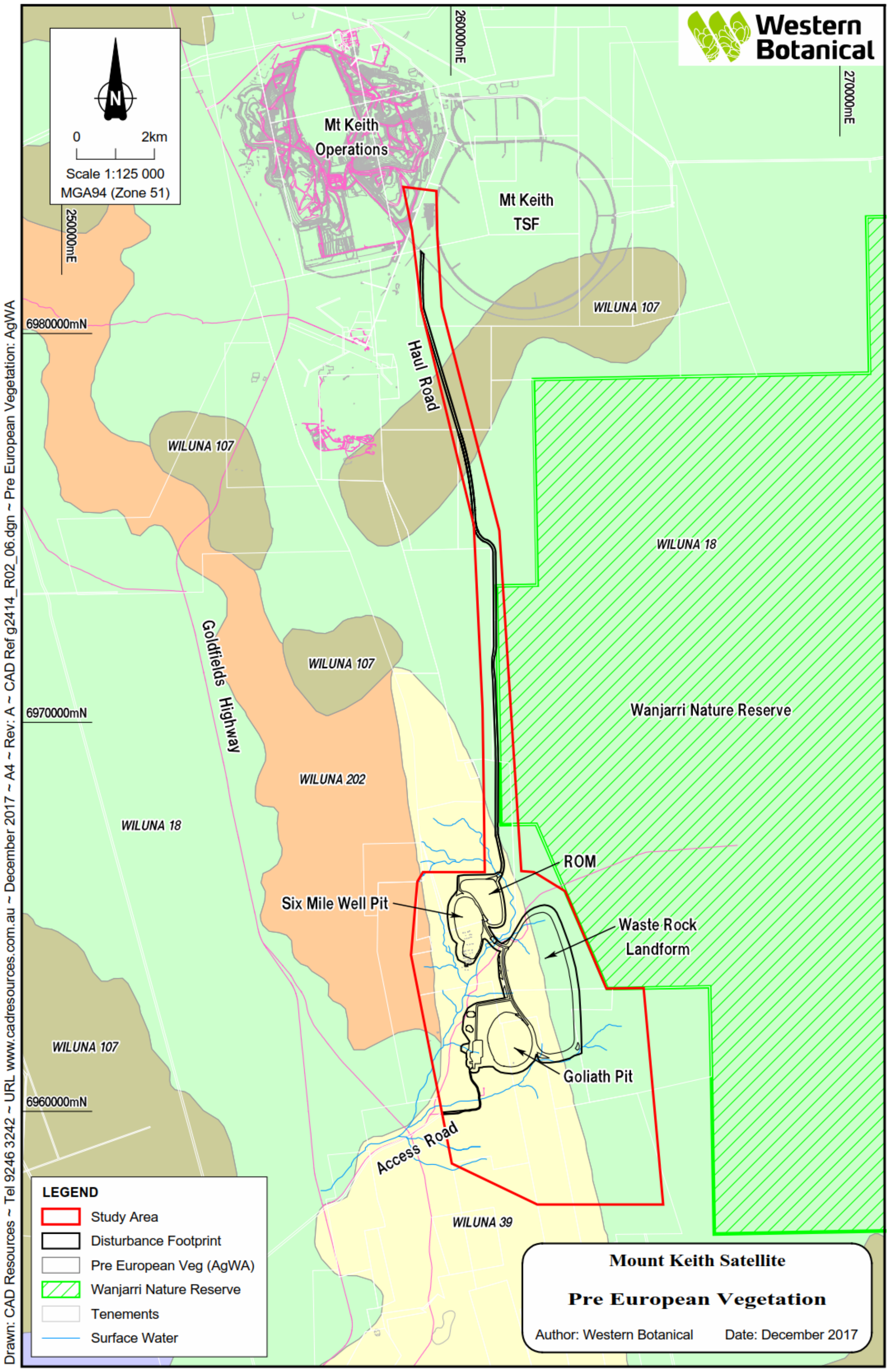


Figure 6 Pre-European Vegetation within Study Area

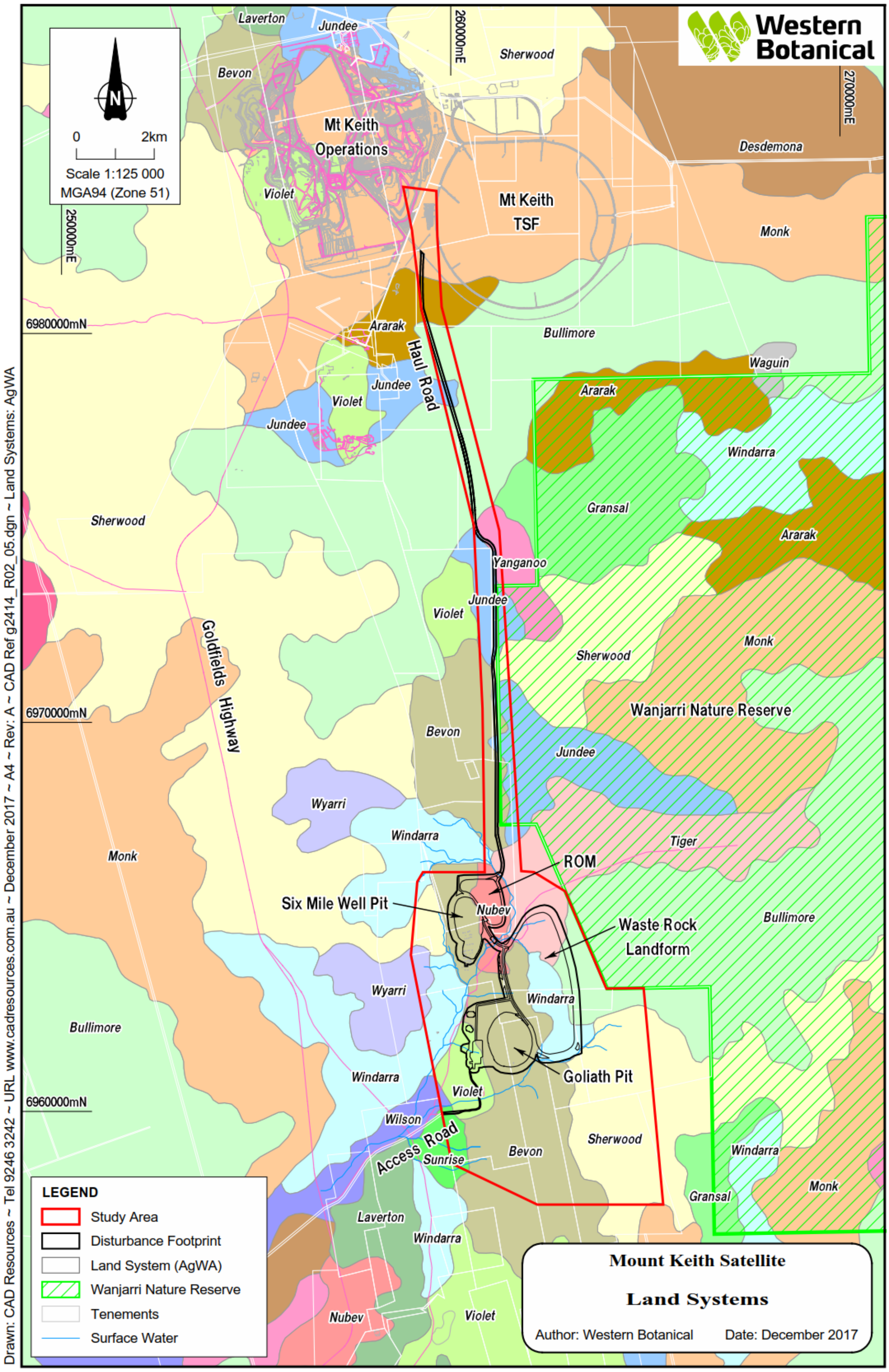


Figure 7 Study Area land systems

Vegetation

As part of the scope of the Western Botanical 2016/17 survey, the Study Area has been remapped at 1:10 000 (compared to previous mapping at 1:25 000) using high quality satellite and aerial photography. This was supported by additional traverses, quadrats and relevès described in Western Botanical (2017) and has resulted in reclassification of many vegetation units and a significantly more accurate description of vegetation unit boundaries.

Thirty-eight Vegetation Associations and four Vegetation Association Complexes, have been recognised in the Study Area. The Vegetation Associations have been grouped into six sub-units according to the dominating underlying geology / regolith which strongly influences the vegetation association species composition (Table 13, Figure 8 and Figure 9).

Those vegetation associations on Sandplains (five communities) and Colluvial and Alluvial Landforms are widely distributed in the Murchison Biogeographic region. Vegetation Associations of the Limonitic Landforms; the fresh rock Basalt geology of the Perseverance fault line; and carbonate soils derived from weathered basalt geology as well as some of the colluvial slopes associated with these, are less widely distributed. Based on information available to date, these are constrained within the Perseverance fault line and within the boundaries of the Violet Ranges Priority Ecological Community. While narrow in an east-west orientation, these landforms extend for over 80 km in a north-south orientation (Western Botanical, 2017).

Table 13 Vegetation Associations of the Study Area

Veg Code	Vegetation Association Name	Area within MKS Study Area (ha)	% of MKS Proposal Study Area	Area (ha) within MKS Development Envelope	% within MKS Development Envelope
Basalt Geology Landform (Fresh Rock)					
BaMAS Complex	Basalt, mixed Acacia species Shrubland Complex	182.9	3.37	0.33	0.03
BaAdS	Basalt, Acacia doreta long phyllode form Shrubland	19.4	0.36	0.86	0.07
BaAxS	Basalt, Acacia aff. xanthocarpa Shrubland	83.2	1.54	9.73	0.77
BaAbS	Basalt, Acacia burkittii Shrubland	11.9	0.22	0.00	0.00
BaCdS	Basalt, Calytrix desolata low Shrubland	22.7	0.42	0.00	0.00
Weathered Basalt Landforms (Carbonate Soils)					
GHPS	Weathered Basalt, Hakea leucoptera subsp. sericipes - Eremophila pantonii Shrubland	233.19	4.32	107.44	8.53
SSS	Stony Senna Shrubland	127.71	2.37	54.64	4.34
EGPW	Weathered Basalt, Eucalyptus gypsophila - Eremophila pantonii Woodland	11.92	0.22	5.16	0.41
Limonitic Landforms					
SILS	Stony Ironstone Low Shrubland	27.17	0.50	2.37	0.19
SIMS	Stony Ironstone Mulga Shrubland	412.28	7.60	254.86	20.24
USBS	Upland Small Bluebush Shrubland	92.93	1.71	32.67	2.59
Archaean Granite Landforms					
BrCP Complex	Breakaway Chenopod Plain Complex	12.23	0.23	0.41	0.03
BrCP – TectS	Breakaway Chenopod Plain Complex - Tecticornia Shrubland	0.58	0.01	0.00	0.00
BrCP-FRAN	Breakaway Chenopod Plain Complex - Frankenia Shrubland	8.46	0.16	0.00	0.00
BrGP	Breakaway Grassy Plain	18.70	0.35	0.00	0.00
BrX-FOL	Archaean Granite Breakaway Footslope	15.71	0.29	0.00	0.00
BrX	Archaean Granite Breakaway	7.08	0.130	0.00	0.00
BrX-P	Archaean Granite geology	30.79	0.57	2.85	0.23

Veg Code	Vegetation Association Name	Area within MKS Study Area (ha)	% of MKS Proposal Study Area	Area (ha) within MKS Development Envelope	% within MKS Development Envelope
GrEx	Granite, Exfoliating granite outcrops	62.4	1.15	0.00	0.00
GrMS	Granitic Mulga Shrubland	990.0	18.26	35.19	2.80
GrMS - BRX Complex	Granite Mulga Shrubland - Granite Breakaway Plateaux Complex	48.3	0.89	0.00	0.00
SAES	Stony Acacia Eremophila Shrubland	484.25	8.93	80.76	6.41
SGRS	Sandy Granitic Mulga Shrubland	5.37	0.10	0.00	0.000
Sandplain Landforms					
MUWA	Mulga - Wanderrie Grassland	2.75	0.05	0.00	0.00
SAMU	Sandplain Mulga Spinifex Shrubland	172.04	3.17	16.16	1.28
SAWS	Sandplain, Acacia species Spinifex Shrubland	11.92	0.22	0.00	0.00
SAMA	Sandplain, Mallee, Acacia species Spinifex Shrubland	13.27	0.24	0.00	0.00
WABS	Wanderrie Bank Grassy Shrublands	182.23	3.36	36.22	2.88
WABS – SAMU Complex	Wanderrie Bank Grassy Shrublands / Sandplain Mulga Spinifex Shrubland Complex	153.89	2.84	20.57	1.63
Colluvial and Alluvial Drainage Landforms					
DRES	Drainage Line Eucalypt Woodland	50.46	0.93	3.79	0.30
DRMS	Drainage Line Mulga Shrubland	381.54	7.04	37.67	2.99
GRMU	Groved Mulga Woodland	65.21	1.21	5.51	0.44
HMCS	Mulga Shrubland with scattered low Chenopod Shrubs	24.00	0.44	0.00	0.00
HPMS	Hardpan Mulga Shrubland	323.35	5.96	102.73	8.16
HPMS THOMA	Hardpan Mulga Shrubland with Acacia thoma co-dominant	3.02	0.06	3.02	0.24
MMS	Mulga over Maireana triptera Shrubland	329.99	6.09	259.82	20.64
MPS	Maireana pyramidata Shrubland	6.83	0.13	0.00	0.00
SMS	Stony Mulga Shrubland	763.84	14.16	186.25	14.79

The majority of Vegetation Associations each represent less than 10% of the area of occupancy within the Study Area and most are well represented and extensive outside the Study Area. However, colluvial slopes mapped as Stony Mulga Shrubland, SMS, (763.84 ha, 14.09%) and the Granitic Mulga Shrubland, GrMS, (990.02 ha, 18.26%) exceed this. Large areas of colluvial slopes, being equivalent to the SMS community, are known from north of the Mt Keith nickel mine to Leinster, though they may have been mapped as Stony Ironstone Mulga Shrublands (SIMS) lower slopes in these areas (Cockerton & Stratford 1997a, 1997b, Western Botanical, 2016). The GrMS Vegetation Association is widespread in the region and is found extensively outside the MKS Proposal Study Area in both eastern and western directions, including within the Wanjarri Nature Reserve, in association with the Archaean granitoid Barr-Smith Range.

Vegetation condition was recorded in May 2016 using the Vegetation Condition Scale adapted from Keighery, 1994, to account for rehabilitated former exploration sites, which showed capacity for regeneration post disturbance (Appendix F, Table 4).

The MKS tenements have been extensively explored in the past and post exploration rehabilitation is found to have been largely effective. Vegetation condition outside the areas directly impacted by exploration and track maintenance is considered as being in “Pristine” condition with little evidence of pastoral activities. Areas having been disturbed in previous exploration works are regarded as being in Excellent condition while completely cleared areas were recorded as Completely Degraded (Figure 10) (Western Botanical, 2017).

The Proposal lies within the Yakabindie Pastoral Lease and grazing of cattle has historically been the main pastoral activity in the past 20 years (D. Brownlie pers. comm., 2016). While there is evidence of traffic by cattle, this is mostly on the margins and within the sandy bed of Jones Creek. Little evidence of grazing pressure on vegetation is apparent. Specifically, the Mulga and associated vegetation shows little evidence of grazing by cattle and the canopies of most vegetation is intact and reflects normal seasonal conditions in all the surveys that have been conducted to date by Western Botanical and Landcare Services since 1996.

Priority Ecological Community

The Study Area lies approximately centrally within the 19,256.2 ha *Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation)* Priority 1 Priority Ecological Community (PEC). This PEC extends for approximately 32 km in a north-south orientation and approximately 11 km in an east-west orientation at its widest point (Figure 11).

The Study Area intersects 3,248.5 ha or 16.87% of the 19,256.2 ha Violet Ranges PEC and the proposed Development Envelope represents 1242 ha or 5.24% of the Violet Ranges PEC as currently mapped. Minimal historical impacts to the Violet Ranges PEC have occurred to date with clearing for pastoral tracks and fences as well as historical mining activities at the decommissioned Bellevue mine site on the north-shore of Lake Miranda being the major contributors. The majority of the geology within the Violet Ranges PEC is basalt, gabbro, and granite with only minor chert and quartz outcrops present with extensive laterite duricrust capping present (Western Botanical, 2017).

The vegetation associations associated with the Mt Keith - Perseverance fault line within the vicinity of the Proposal Area are constrained within the boundaries of the Violet Ranges Priority Ecological Community. However, while narrow in an east-west orientation, these landforms extend beyond the limits of current mapping of the PEC. These additional areas extend in a discontinuous fashion both northward (north of NMK) and southward (to the Leinster nickel mine) directions for an overall inclusive length of approximately 82 km. The Violet Ranges PEC represents approximately 40% of this overall range. Surveys identified that the vegetation analogous with the Violet Ranges PEC extended beyond the currently mapped area of the PEC.

Wanjarri Nature Reserve

The vegetation within the Wanjarri Nature Reserve is contiguous with the eastern margin of the MKS tenements and is reflective of underlying granitoid landscapes with extensive Aeolian sandplains, extensive Archaean granite breakaways and associated saline footslopes and hardpan plains being present. These landscape units are widespread and prevalent in the north eastern Goldfields region and are well represented both within and outside the adjacent Wanjarri Nature Reserve. The Proposal will not directly impact flora and vegetation within the Wanjarri Nature Reserve.

Flora

The Study Area is known to support 393 endemic flora species (and putative hybrids) from 140 genera and 51 families, within 38 Vegetation Associations and two Vegetation Complexes. This is comparable to the species count known at Leinster where 402 endemic species were recorded in studies for WMC Resources (now NiW). The range of species known within each of the Vegetation Associations at MKS ranges from between six and 36 species with a mean of 17 species per Vegetation Association and a standard deviation of six. This is not considered to be either particularly diverse nor to represent a high degree of endemism for the region, and rather is representative of what may be commonly encountered in the eastern Murchison biogeographic region.

Dominant families include Fabaceae (76 species including putative hybrids), Poaceae (47 species), Chenopodiaceae (46 species), Scrophulariaceae (37 species), Asteraceae (30 species), Malvaceae (22 species), and Myrtaceae (20 species). Dominant genera were *Acacia* (53 species inclusive of 31 species and numerous putative hybrids of Mulga species), *Eremophila* (37 species), *Maireana* (18 species), *Senna* (14 species), *Sida* (11 species), and *Eragrostis* (7 species). Excluding putative hybrids, the Study Area supports 13 species of Mulga and related taxa. Of these, the majority are common, widespread in distribution and are highly representative of the flora of eastern Murchison and western Great Victoria Desert biogeographic regions (Western Botanical, 2017).

Conservation significant flora

No Threatened Flora as listed under the *Wildlife Conservation Act 1950* (as amended) are known within, or nearby the Study Area.

Thirteen Priority Flora species were initially known within the Study Area. Following the Western Botanical (2017) survey, a species discussed therein as “undescribed species with limited distribution”, *Eremophila* sp. long pedicels (G. Cockerton 1975), has since been listed by DBCA as a Priority 2 species (G Cockerton, 2017, pers.comms.17 November). This takes the total known Priority Flora within the Study Area to 14, which includes one Priority 1, two priority 2, eight Priority 3, and three Priority 4 listed species (Table 14).

Table 14 Priority flora recorded during surveys

Taxon	Priority	Distribution
Anacampseros sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248)	P1	Granitoid domains.
Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771)	P2	MKS Development Envelope (transport corridor) and Study Area, associated with granitoid breakaways and laterite capped hills.
Eremophila sp. long pedicels (G. Cockerton 1975)	P2	Around 20 individuals are known within the northern portion of the proposed haul road alignment to Mt Keith, on the south-western margin of the Mt Keith Central Discharge Tailings Storage Facility (CDTSF) on hardpan plains and adjacent sandplain.
Aristida ?jerichoensis var. subspinulifera	P3	1 record in Jones Creek that has been identified.
Gunniopsis propinqua	P3	Several records in the Proposal Development Envelope and Study Area, saline areas downslope of granitoid breakaways. Recorded in the Study Area for the first time in 2016.
Hibiscus krichauffianus	P3	Three records within the MKS Development Envelope and Study Area. Recorded in the Study Area for the first time in 2016, stony landscapes.
Hybanthus floribundus subsp. *chloroxanthus*	P3	Scattered populations in the Proposal Development Envelope and Study Area, mostly in drainage areas.
Sida picklesiana	P3	Proposal Development Envelope and Study Area, granitoid breakaways.
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	P3	Proposal Development Envelope and Study Area, granitoid breakaways, SIMS and SILS communities.
Tribulus adelacanthus	P3	One record within the Proposal Development Envelope on colluvial slopes.
Verticordia jamiesonii	P3	Proposal Development Envelope and Study Area, granitoid breakaways.
Eremophila pungens complex , inclusive of E. sp. Leinster (R.J. Cranfield 6767)	P4	Low numbers, widespread in the Proposal Development Envelope and Study Area, granitoid breakaways and limonitic landforms.
Grevillea inconspicua	P4	Low numbers, widespread in the Proposal Development Envelope and Study Area, associated with outcropping basalt.
Hemigenia exilis	P4	Low numbers, widespread in the Proposal Development Envelope and Study Area, associated with creeklines and volcaniclastic sediments.

Species of interest

Several species of interest have been identified within the Study Area and are briefly described in Table 15. The majority of these are well known and widespread in distribution within the region. However, some species require formal vouchering or taxonomic review (Western Botanical, 2017).

Table 15 Species of interest within Proposal Area

Species of interest	Description
Undescribed species with limited distribution	
Eremophila sp. long pedicels (G. Cockerton 1975),	Known from four subpopulations in the Lake Way and Lake Maitland Catchments in the Wiluna area. Around 20 individuals are known within the northern portion of the proposed haul road alignment to Mt Keith, on the south-western margin of the Mt Keith CDTSF. A recent review of the taxon has found additional material in the region, however, investigation of the WA Herbarium specimens by Western Botanical conducted in early March 2017 found many anomalies and those specimens at distance from the Wiluna region are not considered to be the same species. DBCA have since reviewed the WA Herbarium specimens, amended the distribution and listed this species as P2 (G. Cockerton, 2017, pers. comm. 17 November), as listed Table 14.
Widely distributed undescribed species	
Acacia oswaldii (long phyllode variant) (G. Cockerton & S. Cockerton WB38622); *Maireana tomentosa* - (Type 1 breakaway foot slopes) (G. Cockerton & D. Brassington WB38650); *Olearia* sp. Sherwood Breakaways (A. Taylor 25552); *Olearia xerophila* sens. lat. (G. Cockerton & P. Goodman WB38116); *Ptilotus obovatus* (typical Goldfields form) (G. Cockerton, J. Grehan, L. Trotter, J. Symington 15213); *Ptilotus obovatus* (upright form) (G. Cockerton, J. Grehan, L. Trotter, J. Symington LCH 15206); *Scaevola spinescens* (broad leaf, non-spiny form); and *Scaevola spinescens* (narrow leaf, spiny form)	The majority of these are well known, represented by numerous specimens at the WA Herbarium (albeit under names other than listed below) and widespread in distribution within the Murchison, Pilbara or Great Victoria Desert biogeographic regions. These do not warrant conservation consideration.
Species with uncertain taxonomic status, requiring taxonomic review	
Acacia doreta long phyllode form (G. Cockerton & S. Cockerton WB38633). *Acacia subtessarogona* (flat pod form) (G. Cockerton WB38658). *Acacia xanthocarpa* (flat phyllode form) (G Cockerton & J Warden WB39702) *Acacia* sp. East Murchison Basalt (G. Cockerton & J Warden WB39701), equivalent to *Acacia quadrimarginea* (narrow phyllode form). *Olearia* sp. Sherwood Breakaways (A. Taylor 25552), currently within *Olearia stuartii*. *Olearia xerophila* sens. lat. (G. Cockerton & P. Goodman WB38116).	Taxonomic status of these species, particularly the first four *Acacia* species is not well understood. An abundant quantity of material was obtained during the 2016 and 2017 rounds of field works which has been submitted to the WA Herbarium for further review by an *Acacia* expert.
Species occurring at limits of known range or representing range extension	
Acacia brachystachya *Eremophila platycalyx* subsp. Neds Creek (N.H. Speck 1228) *Aristida ?jerichoensis* var. *subspinulifera* P3 *Chondropyxis halophila* *Muelleranthus trifoliolatus* *Maireana melanocoma* *Sida* sp. spiciform panicles (E. Leyland s.n. 14/8/90)	These species as recorded in the Study Area represent slight range extensions from known distributions. These species are well represented within Western Australia and do not warrant conservation consideration.

Weeds

Six weed species were recorded, all in small and scattered populations of low numbers (Figure 12). In addition, a wide range of weed species now prevalent at NMK were observed during transit through the mine site as part of the 2016 field surveys. Whilst these lie outside the Study Area, the two sites will be linked by a haul road, with frequent vehicle movements between the two, providing risk of weed ingress into the Proposal Development Envelope. No declared or environmental weeds were identified.

The weeds identified by Western Botanical (2017) are listed in Table 16.

Table 16 Weeds of the Study Area

Weed species	Description
Rumex vesicarius (Ruby Dock)	An aggressive coloniser species that responds rapidly to rainfall, producing seeds that are readily distributed by wind and water. It is well established at Mt Keith and elsewhere on minesites and in disturbed lands in the north-eastern Goldfields.
Cenchrus ciliaris (Buffel Grass)	An aggressive coloniser that is well established in the Pilbara region but is only recently becoming a problem in the north-eastern Goldfields. It is allelopathic, meaning it supresses other plants growing near it and can be a major management risk to the Proposal.
Cenchrus setiger (Birdwood Grass)	Is similar to Buffel Grass and is an aggressive, allopathic coloniser that is well established in the Pilbara region but is only recently becoming a problem in the north-eastern Goldfields.
Bidens bipinnata (Tick Weed)	Recorded within the bed of Jones Creek, downstream from the existing main crossing, and lies within the Study Area. It is a nuisance plant with spiny fruit that cling to clothing and is readily transmitted via stock.
Lysimachia arvensis (Pimpernel)	Recorded at one site within Jones Creek and is a small annual species, which has seeds which are readily transported by wind and water.
Mesembryanthemum nodiflorum (Slender Iceplant)	Recorded at one site in the north-west of the Study Area, associated with a low Archaean granite breakaway. It is a small annual species that has seeds, which are readily transported by wind.

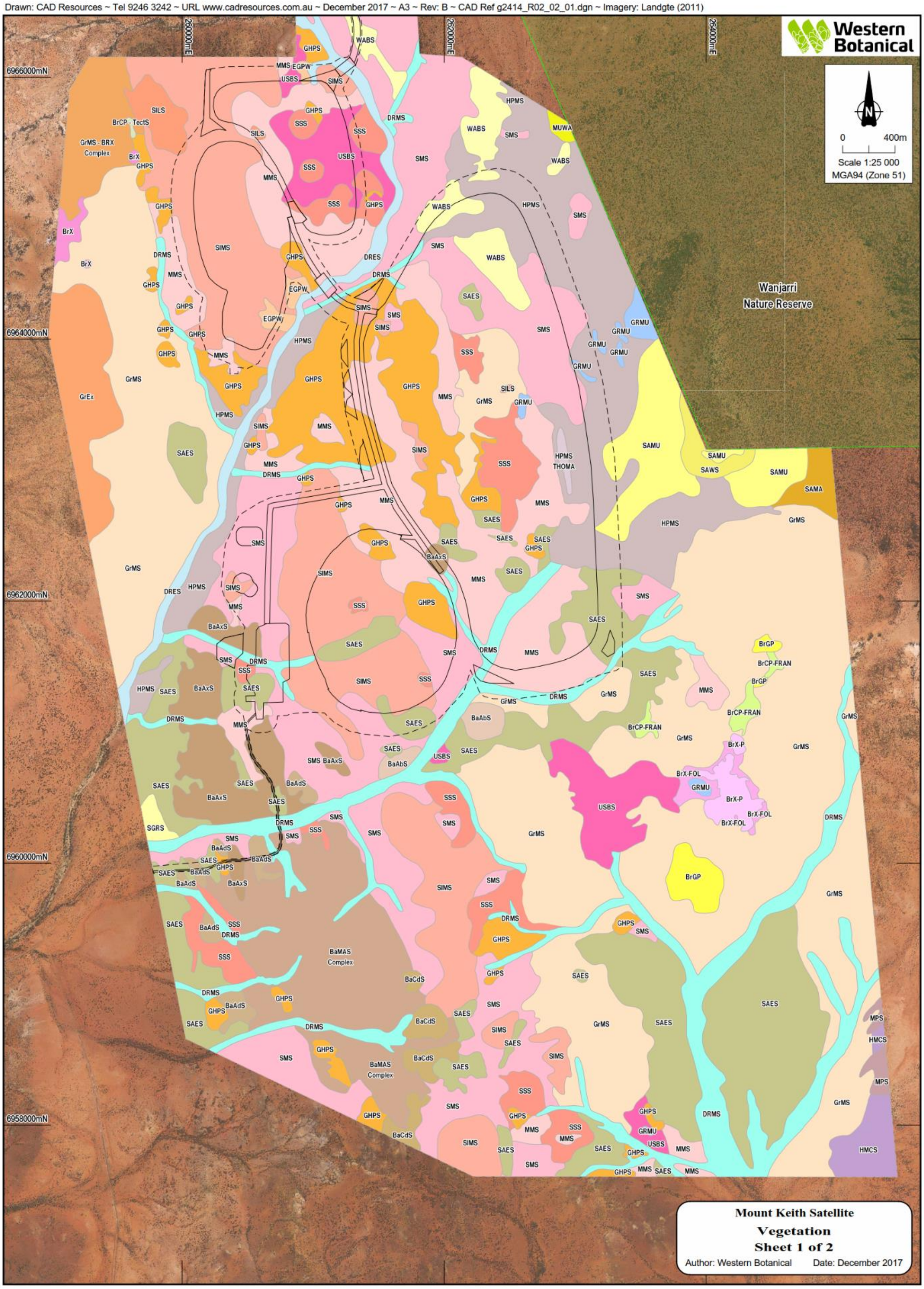


Figure 8 Mt Keith Satellite Proposal Vegetation Mapping Sheet 1

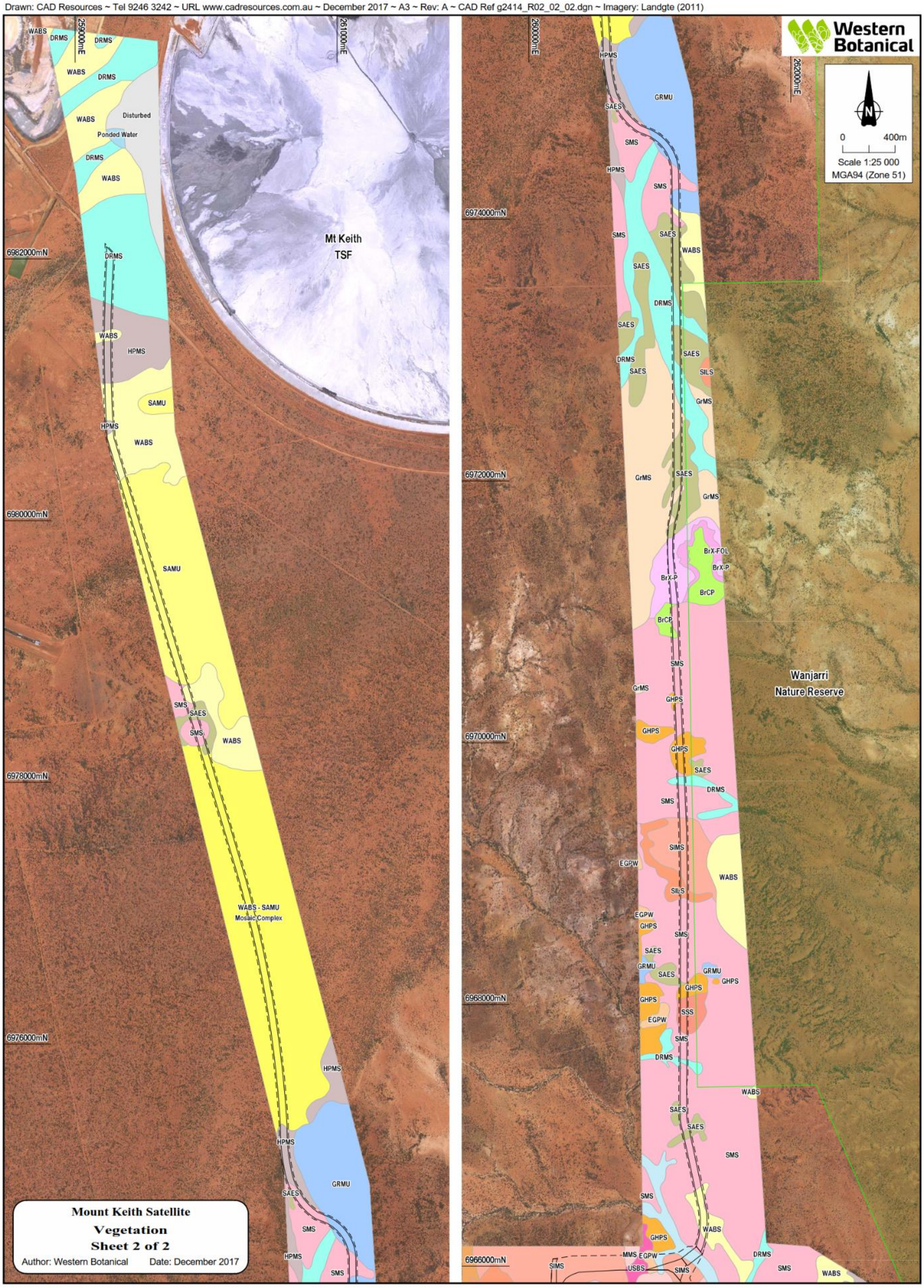


Figure 9 Mt Keith Satellite Proposal Vegetation Mapping Sheet 2

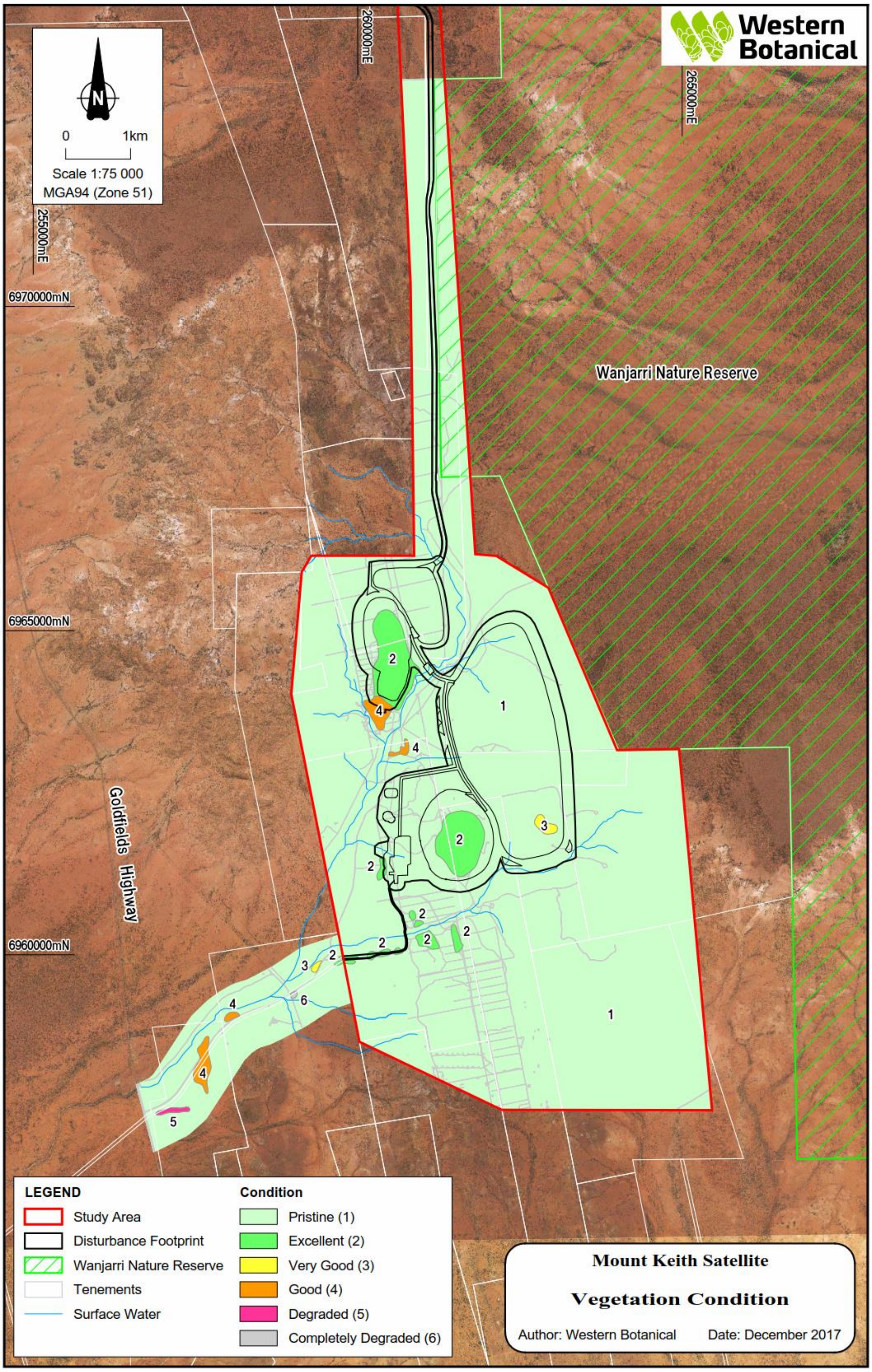


Figure 10 Vegetation condition

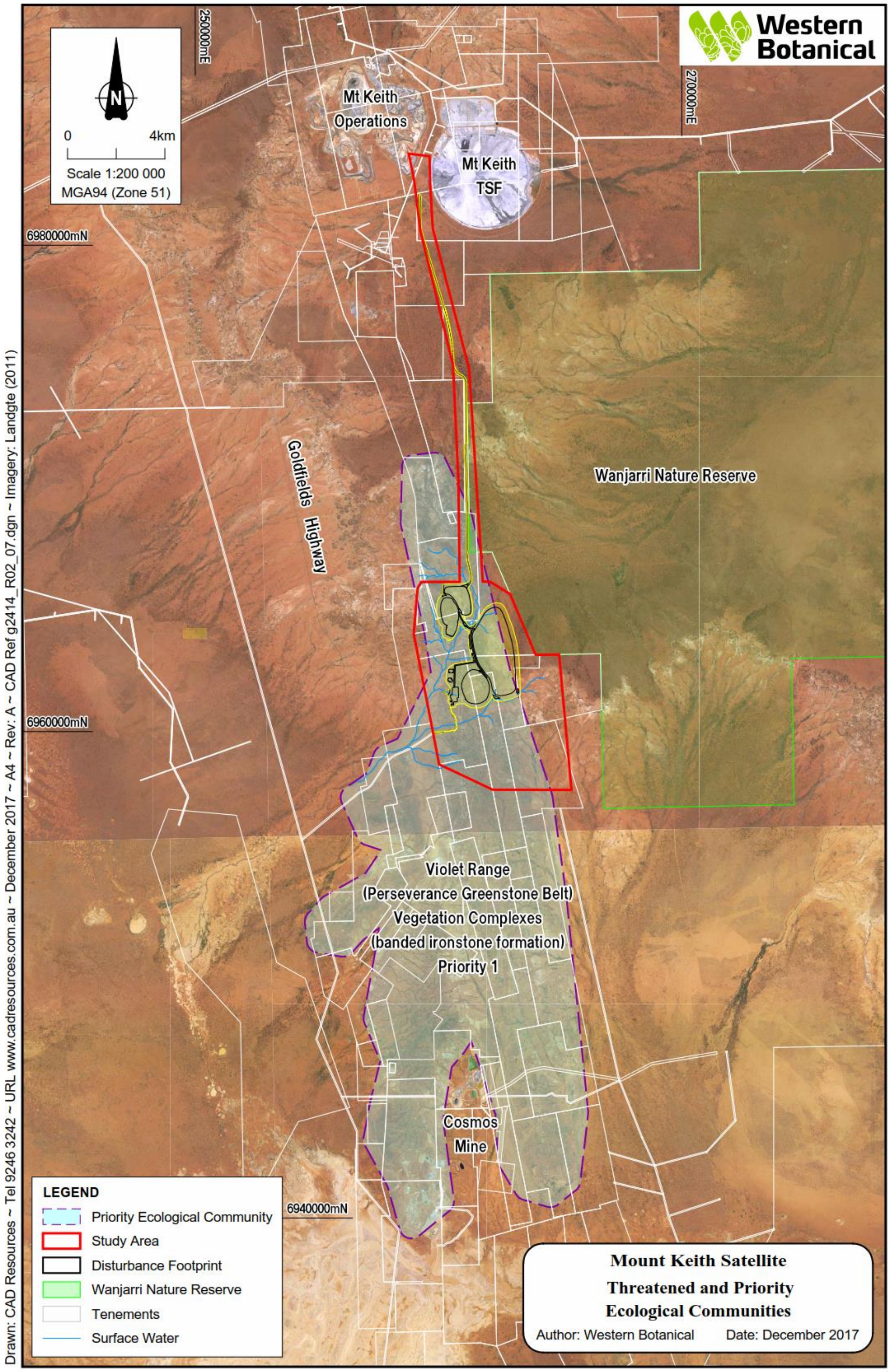


Figure 11 Mt Keith Satellite Study Area and the Violet Range Priority Ecological Community (DBCA)

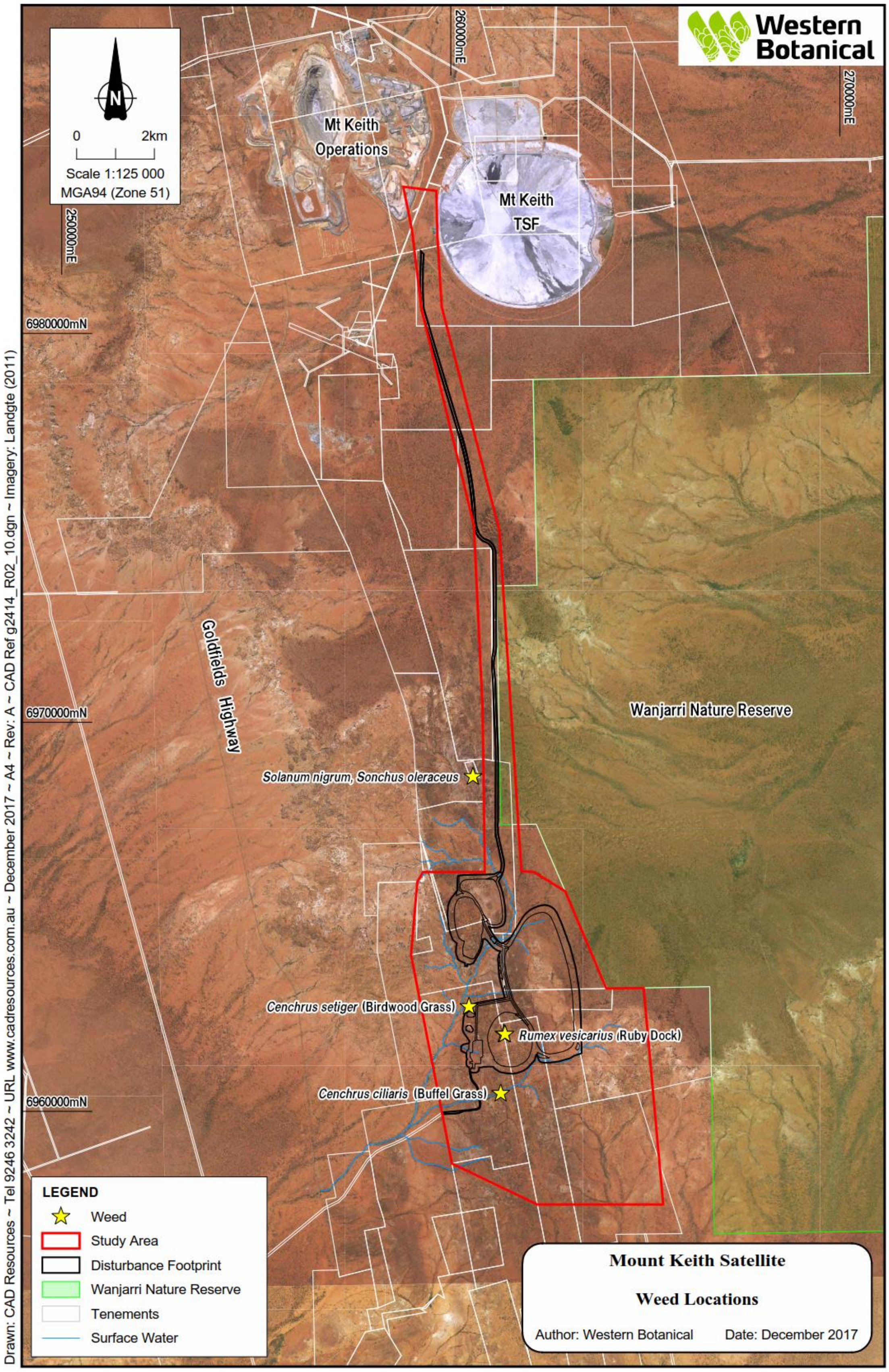


Figure 12 Known Weed Populations within the Study Area

5.3 Potential impacts

A summary of potential impacts of the Proposal on flora and vegetation is provided in Table 17, based on the Proposal description (Section 2.3), the ESD and impact assessment undertaken by NiW. An assessment of the direct and indirect impacts is provided in Section 5.4 below.

Table 17 Summary of potential impacts on Flora and Vegetation

Potential Impacts	Description
Direct	Clearing of up to 878 ha of native vegetation within a Development Envelope of 1259 ha.
	Removal and disturbance of Priority flora and vegetation, including vegetation units associated with the Violet Range Priority Ecological Community (PEC).
Indirect	Potential to spread or introduce weeds.
	Habitat fragmentation.
	Increased risk (altered fire regime) for fire resulting in vegetation loss or change.
	Impacts to adjacent native vegetation, including the Wanjarri Nature Reserve.

5.4 Assessment of impacts

Flora

No Threatened (Declared Rare) flora is known within the Study Area. Fourteen Priority flora are known within the Study Area. The majority of flora species known from the overall Study Area are both common and widespread in the eastern Murchison, western Great Victoria Desert biogeographic regions. The Proposal has been designed to minimise impacts on Priority Flora and development of the Proposal should not result in an upgrading of the Conservation Statius of any of these Priority Flora species.

A further eight species which represent undescribed flora that do not as yet appear on the Census of Vascular Flora for Western Australia are known from within the Study Area. These are species that are widely distributed in the eastern Murchison Biogeographic Region and are known cases of inadequate taxonomy. These species neither have, nor require, conservation focus. One species, *Eremophila* sp. long pedicels (G. Cockerton 1975), represents an undescribed taxon with relatively limited range at NMK and within the Lake Way and Lake Maitland catchments south-east of Wiluna. It also is regarded as being relatively common within its known range (>50,000 individuals estimated in 4 sub-populations) and has recently been listed as Priority 1 flora. The Proposal impacts on a negligible proportion (~20 plants) of the overall known population of this species.

A further group of six undescribed species require taxonomic clarification by expert taxonomists. The Proposal does not impact on the majority of these undescribed taxa. However, *Acacia* sp. East Murchison Basalt (G. Cockerton & J Warden WB39701) and *Acacia xanthocarpa* flat phyllode form (G Cockerton & J Warden WB39702) occurs within the Development Envelope and greater Study Area. These taxa are also known from near Leinster and eastwards to Laverton and westwards to the Booylgoo Range.

Direct impacts on flora

The Proposal requires the clearing of up to 878 ha of native vegetation within a Development Envelope of 1259 ha. In considering direct losses, impacts have been calculated conservatively on the Proposal Development Envelope (Figure 3). The clearing disturbance within the Development Envelope includes areas for proposed mine layout including two pits (Goliath and Six Mile Well), a waste rock landform, ancillary facilities and a haul road corridor from the Proposal area to the existing Mt Keith Mine, as described in Section 2.3.

Of the 14 species of Priority Flora known within the Study Area, five are not directly impacted by the Proposal (Western Botanical, 2017):

- *Anacampseros* sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) P1. – A cryptic species associated with granitoid landforms from Menzies to west of Meekatharra.
- *Aristida jerichoensis* var*. subspinulifera* P3 – This species was recorded at one location within the bed of Jones Creek on the north eastern edge of the Study Area and outside of the Development Envelope (Appendix F, Figure 16).
- *Hemigenia exilis* P4 – while the distribution map within the Study Area shows a point within the Proposal Disturbance Footprint, this is a point generated from the DBCA database. Field surveys at this location and in the vicinity of the record did not locate this species. No plants will be impacted by the Proposal.
- *Sida picklesiana* P3 – A species common on the breakaway landform of the Sherwood Land System between Leinster, NMK and Yeelirrie and on banded ironstones west of Wiluna.
- *Hibiscus krichauffianus* P3 – A total of 7 plants are recorded in the Study Area over 3 sites. The waste rock landform design avoids disturbance of an individual plant within the envelope.

Table 18 lists the impacts of proposed clearing on the remaining 9 listed Priority species.

Table 18 Summary of direct impacts on Priority Flora

Taxon	Priority	Proposed Impact on Number of Plants					Proposed Impact on Number of Populations					Notes
		No of plants within Development Envelope	No. plants within Study Area	No of plants known in Region	% of known local population	% of regional population	No. of Populations within Disturbance Envelope	No. of Populations within Study Area	No. of Populations Known in Region	% of Local Populations	% of Regional Populations	
Eremophila sp. long pedicels (G. Cockerton 1975)	P2	20	20	> 50,000	100.00%	0.04%	1	1	4	100%	25%	20 individuals to be impacted by haul road construction is not considered a significant impact on local population.
Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771)	P2	285	12,287	13,715	2.08%	2.08%	1	1	2	100%	50%	The population is located on the Archaean granite where the proposed haul road intersects the breakaway system and loss of this small proportion will be unavoidable.
Gunniopsis propinqua	P3	Not assessed	> 400	Not assessed	30% of local sites	Not assessed	1	3	15	33%	7%	This species has been found at 7 sites over 3 locations within the Study Area, with many hundreds of individuals estimated per site.
Hybanthus floribundus subsp. *chloroxanthus*	P3	241	461	1,679	52.28%	14.35%	1	1	4	100%	25%	There are 1,679 plants known in total across four populations. The local population extends in a discontinuous fashion in 4 sub-populations from NMK to MKS.
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	P3	806	10,552	59,388	7.64%	1.36%	3	3	14	100%	21%	12 Populations shown on WA Herb database. Three occur within MKS Study Area, all slightly impacted by MKS Haul Road.

Taxon	Priority	Proposed Impact on Number of Plants					Proposed Impact on Number of Populations					Notes
		No of plants within Development Envelope	No. plants within Study Area	No of plants known in Region	% of known local population	% of regional population	No. of Populations within Disturbance Envelope	No. of Populations within Study Area	No. of Populations Known in Region	% of Local Populations	% of Regional Populations	
Tribulus adelacanthus	P3	1 record	> 1	> 173, most not assessed	100%	0.58%	1	1	9	100%	11%	This is a poorly known annual, and while one record lies within the Proposal Development Envelope (nine populations known in total in WA, six appearing on the Florabase website), it is not possible to make a meaningful assessment of proportional impacts on this species.
Verticordia jamiesonii	P3	63	500	> 1,198	12.60%	5.26%	1	2	18	50%	6%	This species found in one location with 63 plants representing 12.6% of the local population and 5.26% of the regional population within the Disturbance Footprint (Figure 16).
Eremophila sp. Leinster (R.J. Cranfield 6767) within Eremophila pungens	P4	138	> 4,359	> 20,000	3.17	< 1%	1	1	7	100%	14%	*Eremophila* sp. Leinster is very abundant at Leinster, within the SIMS habitat unit in the Bevon Land System. Small scattered populations known at MKS and NMK, other regional populations not quantified.
Grevillea inconspicua	P4	27	1,071	8,263	2.52	0.33%	1	1	14	100%	7%	*Grevillea inconspicua* is very abundant within the Violet Ranges, in the Violet Range PEC, with small scattered occurrences within the MKS Study Area.

Five of the species listed in Table 18 (*Eremophila* sp. Leinster (RJ Cranfield 6767), *Grevillia inconspicua, Hibbertia* sp., Sherwood Breakaways (RJ Cranfield 6771), *Thryptomene* sp. Leinster (BJ Lepschi & LA Craven 4362), *Verticordia jamiesonii*) have minor proportions of populations within the Development Envelope and are impacted at less than 6% of their known local populations and less than 3% of the regional populations.

The P2 species, *Eremophila* sp. long pedicels (G. Cockerton 1975) is known from four populations in the Lake Way and Lake Maitland Catchments in the Wiluna area. The regional known population of Eremophila sp. long pedicels is estimated at over 50,000 individuals (Western Botanical, 2017). An estimated 20 plants of Eremophila sp. long pedicels lie within the proposed haul road alignment to Mt Keith (restrained by tenure) and will be disturbed (Figure 13). The proposed disturbance represents 0.04% of the known population.

The P2 species *Hibbertia* sp. Sherwood Breakaways (RJ Cranfield 6771), population is traversed by the proposed haul road alignment (Figure 14). In response to the anticipated Priority status of this species in early October 2017, NiW narrowed the haul road footprint as it passes through the edges of the breakaway landform where these plants are located (Section 5). This deviation has reduced the impact to 285 individuals of this species, which represents 2.08% of the known local and regional populations. The estimated total population of the species is 13,715 plants. Approximately 89.59% of the population of this species occurs to the west of the haul road on Yakabindie Station. The remaining 10.41% (1,428 plants) occurs within the Wanjarri Nature Reserve, which is considered a sizeable population. The overall impact to this species on local and regional scale is considered minor. Following supply of survey data and specimens to DBCA and the WA Herbarium in late 2017, the status of this species has been updated to P2 (pers. comm. Geoff Cockerton, 10 April 2018).

Two populations of *Hibbertia* sp. Sherwood Breakaways are recognised, separated due to cadastral boundaries (Population 1 on Wanjarri Nature Reserve, WNR, vs. Population 2 on Yakabindie Station). Within the two populations, sub-populations of *Hibbertia* sp. Sherwood Breakaways are naturally disjunct, separated by gaps of 200m to 700m, reflecting the dissection of the landscape and the disjunctions in suitable habitat supporting the species. Population 1 within WNR demonstrates disjunctions of up to 250m between groups of plants but has been mapped as one population as the habitat likely to support the species is reasonably continuous. Population 2 on Yakabindie Station can be arbitrarily mapped into six sub-populations where disjunctions in occurrence of plants of over 200m occur, or where discontinuity of habitat likely to support the species exists.

There are significant numbers of *Hibbertia* sp. Sherwood Breakaways occurring on either side of the proposed haul road alignment (Figure 22). To the east, within the WNR, the estimated population of 1,428 plants has a spatial disjunction from the proposed haul road and Population 2 within Yakabindie Station. The closest point of the WNR population to the proposed haul road alignment is 340m. This populations lies east of a drainage divide and is therefore considered secure. The six sub-populations on Yakabindie Station each support hundreds to thousands of plants in most cases, though one sub-population consists of one isolated plant, just below the summit of a laterite capped hill at the south-eastern edge of the population. Development of the haul road alignment will cut-off the eastern edge of the north-eastern sub-population (sub-population 2.1) supporting approximately 428 plants (3.12% of the overall population).

Given the natural disjunctions between the sub-populations of the species, the issue of fragmentation of the population on a local scale arising from development of the proposed haul road may only affect the 428 plants outside the Development Envelope on the eastern side of the haul road alignment within Population 2.1. The potential disjunction here reflects natural disjunctions already observed within the existing population.

The flora of the breakaway landscape is naturally sparse with large gaps between plants and groups of plants of a range of species. Species tend to flower rapidly after sufficient rainfall, often following thunderstorm or cyclonic rainfall events. *Hibbertia*, and the majority of other species found on the breakaways, are insect pollinated. The specific pollinators of *Hibbertia* sp. Sherwood Breakaways have not been studied, though are expected to include native bees, moths, wasps, flies, and beetles. Gaps in populations of insect pollinated species with commensurate flowering phenology may result in barriers to gene flow amongst disjunct populations of these species. Further, depending on the biology and behaviour of those insects which effectively pollinate *Hibbertia* in this landscape, gaps between sub-populations may represent partial or total barriers to regular gene transfer. This aspect has not been assessed in the case of *Hibbertia* sp. Sherwood Breakaways. Observations in July 2017 demonstrated highly effective seed set throughout the population of *Hibbertia* sp. Sherwood Breakaways with all plants having set and distributed large amounts of viable seed. Whether disjunctions represent barriers to gene flow or not, *Hibbertia* sp. Sherwood Breakaways plants set large amounts of seed in good seasons, demonstrating effective pollination in the in-situ populations.

The P3 species *Gunniopsis propinqua* is known from seven sites within three locations in the Study Area. The largest of these lie north-west of the Six Mile Well orebody area (four sites) and east of the proposed haul road alignment route over the breakaways north of the Six Mile orebody area (two sites) with many hundreds of individuals estimated at each site. Both lie downslope of Archaean granite breakaways and associated kaolinised slopes, outside the proposed Development Envelope. The eastern population extends into the Wanjarri Nature Reserve with an estimated several thousand plants over hundreds of square metres present. The third population at MKS (one site) lies within the proposed WRL adjacent to the six mile orebody area, with no population size estimated here. Regional population estimates from the known sites outside of MKS have not been undertaken. Given that *Gunniopsis propinqua* is a very small, short-lived ephemeral and is difficult to survey, it is easily overlooked in the field. It is highly likely the species is under-represented in botanical surveys and is therefore thought to be more common and widespread than records indicate (Western Botanical, 2017).

The P3 species *Hybanthus floribundus* subsp. *chloroxanthus* population that will be impacted sits within the Six Mile Orebody (Figure 15). Populations are also known from the south-eastern portion of the Murchison Biogeographic Region, including Yakabindie Station, near Murrin Murrin minesite east of Leonora, one near Leinster and one on Weebo Station (Western Botanical, 2017). There are 1,679 plants known in total, inclusive of regional populations, of which 241 individuals exist within the Development Envelope, representing 14.35% of the known population.

The P3 species of *Verticordia jamiesonii* population that will be impacted consists of 63 plants (5.26% of overall enumerated population) and lies within the proposed haul road alignment over a breakaway (Figure 16). One population of 500 plants occurs on the low breakaways within the south-east portion of the Study Area and outside of the Study Area a fragmented population of approximately 326 plants occurs approximately 4.5km north of the Study Area. Additional populations north of Mt Keith containing an unquantified number of plants are also known.

The P3 species *Hibiscus krichauffianus* will not be directly impacted by the Proposal. *Hibiscus krichauffianus* was recorded at three sites, one lying within the development envelope at the toe of the proposed WRL east of the Goliath orebody area (Figure 17). A total of seven plants were recorded at MKS, one being within the proposed Disturbance Envelope. The actual Waste Rock Landform design will however not impact on this individual. The MKS record (three sites) represents the seventh record for the species in Western Australia.

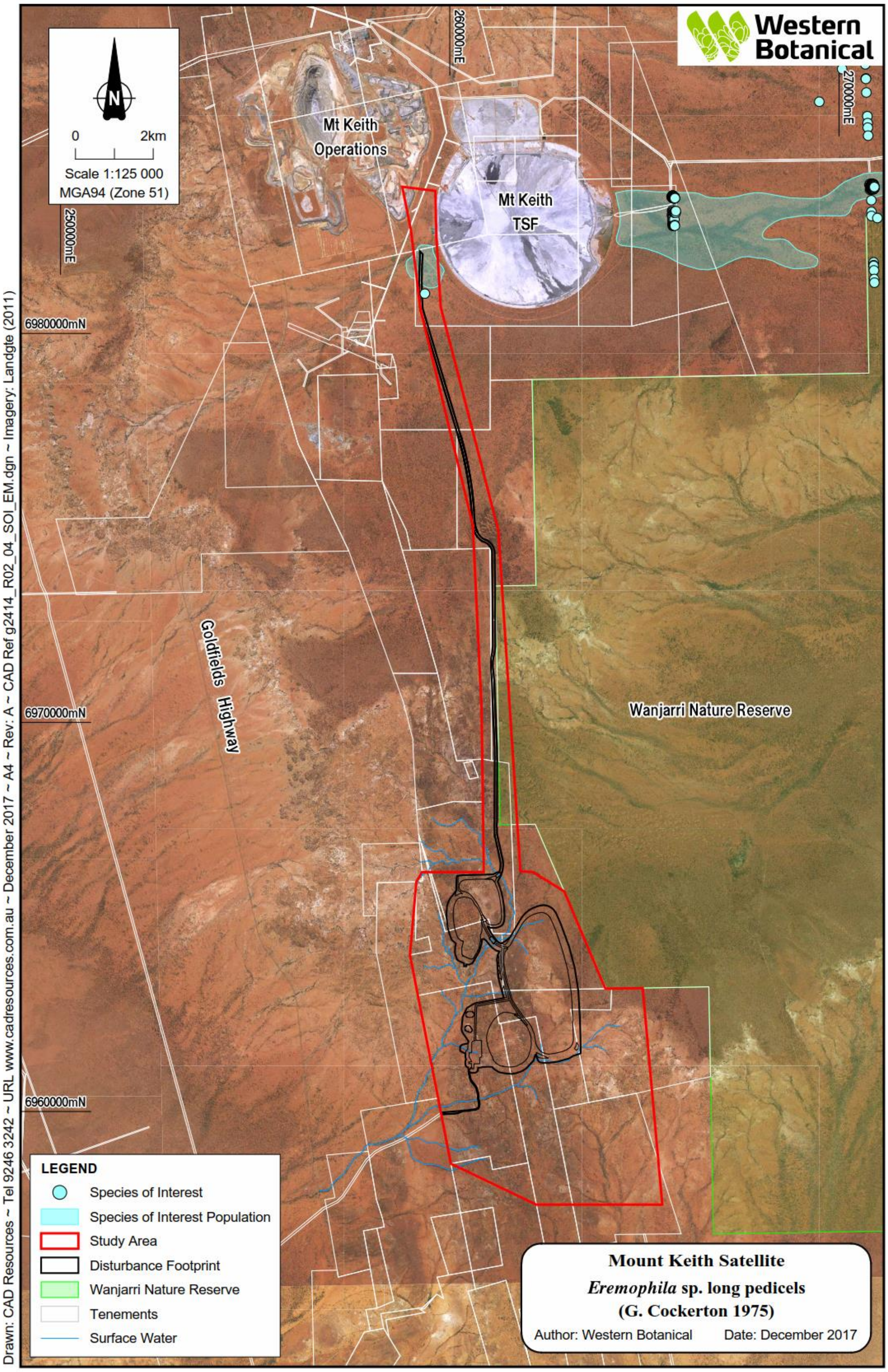


Figure 13 Mt Keith Satellite Proposal Known distribution of Eremophila sp.long pedicals (G.Cockerton 1975)

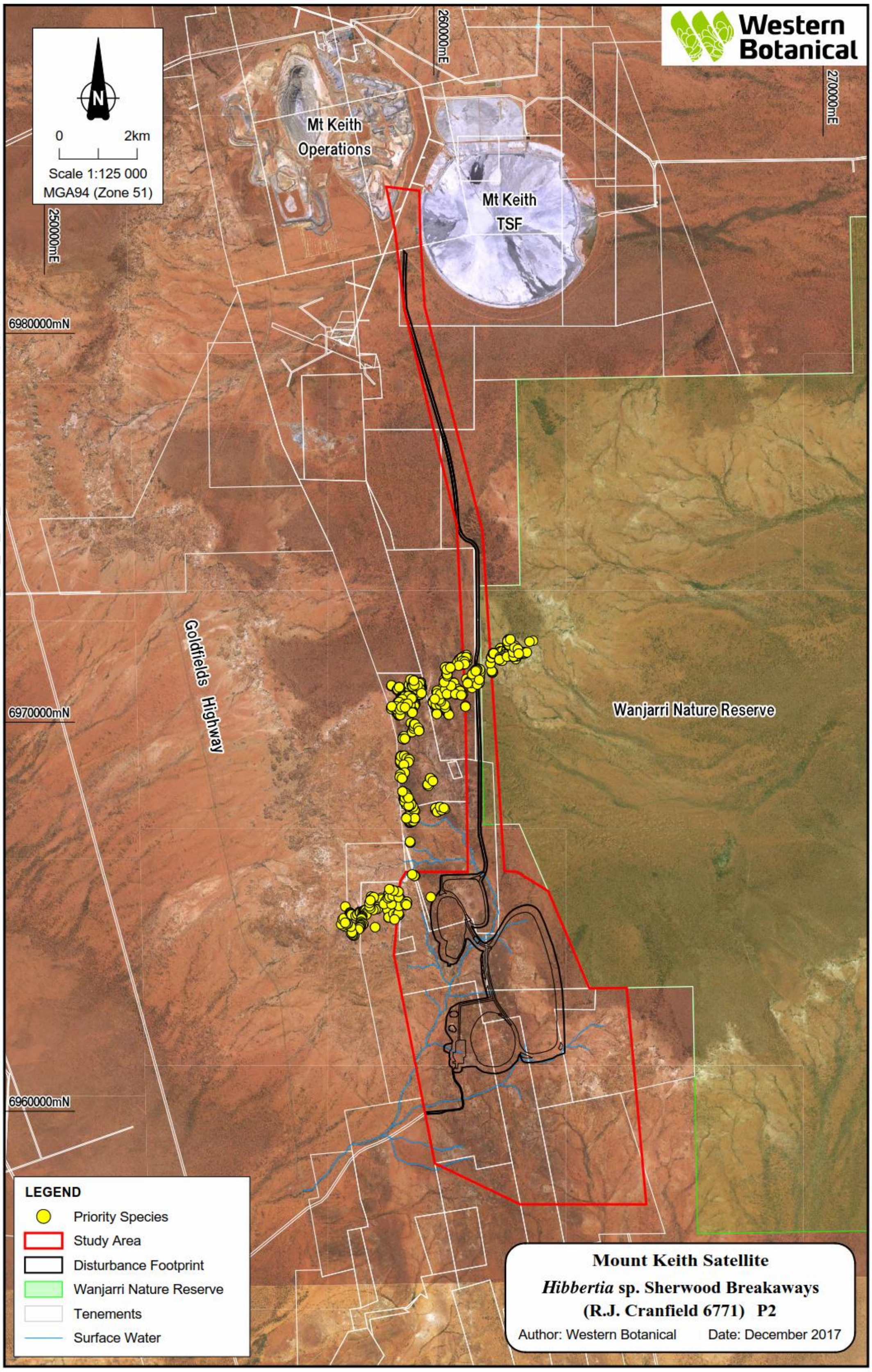


Figure 14 Mt Keith Satellite Proposal Known distribution of Hibbertia sp. Sherwood Breakaways (R.J. Cranfield 6771)

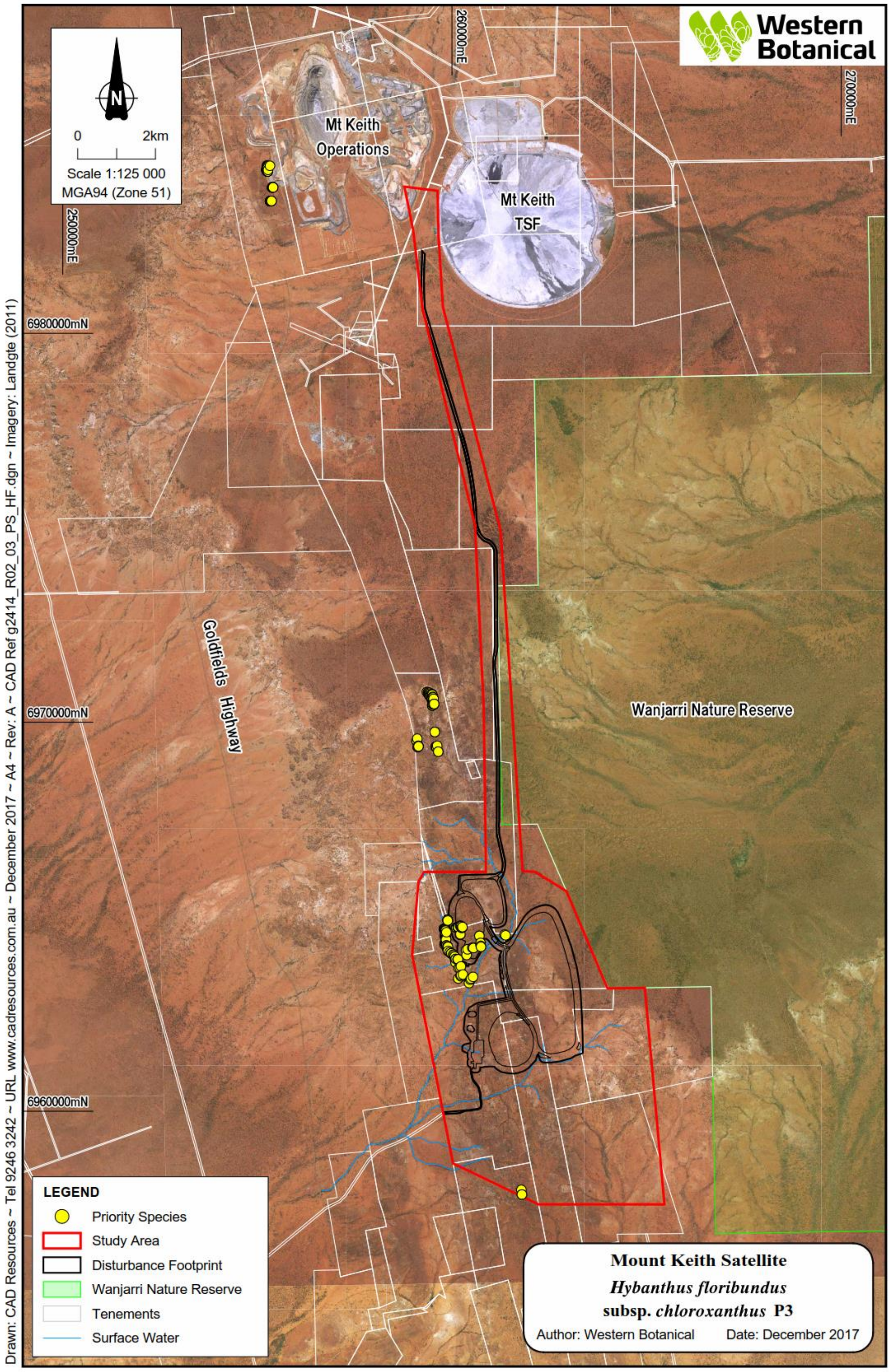


Figure 15 Mt Keith Satellite Proposal Populations of Hybanthus floribundus subsp. Chloroxanthus

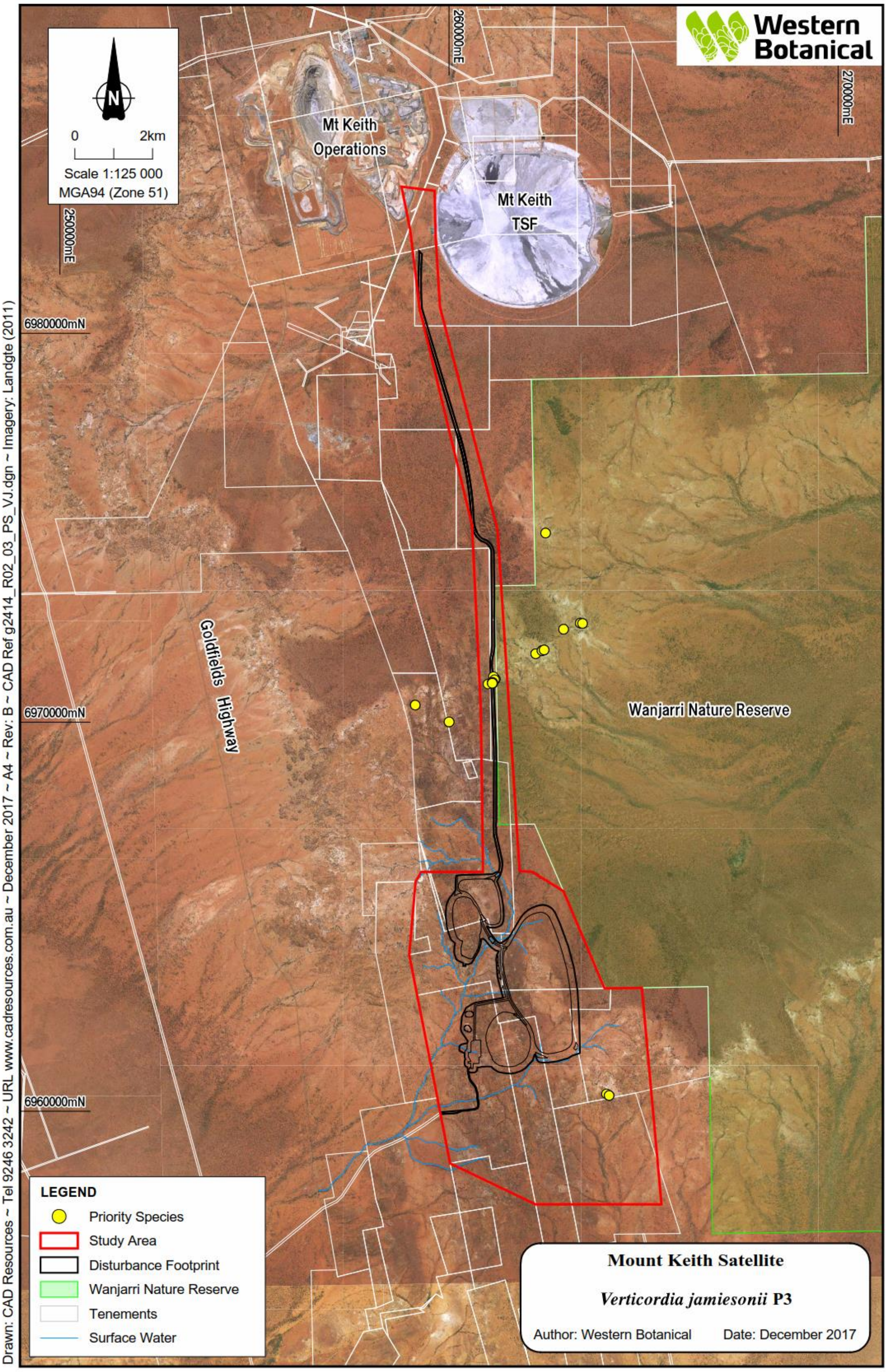


Figure 16 Mt Keith Satellite Proposal Known distribution of Verticordia jamiesonii

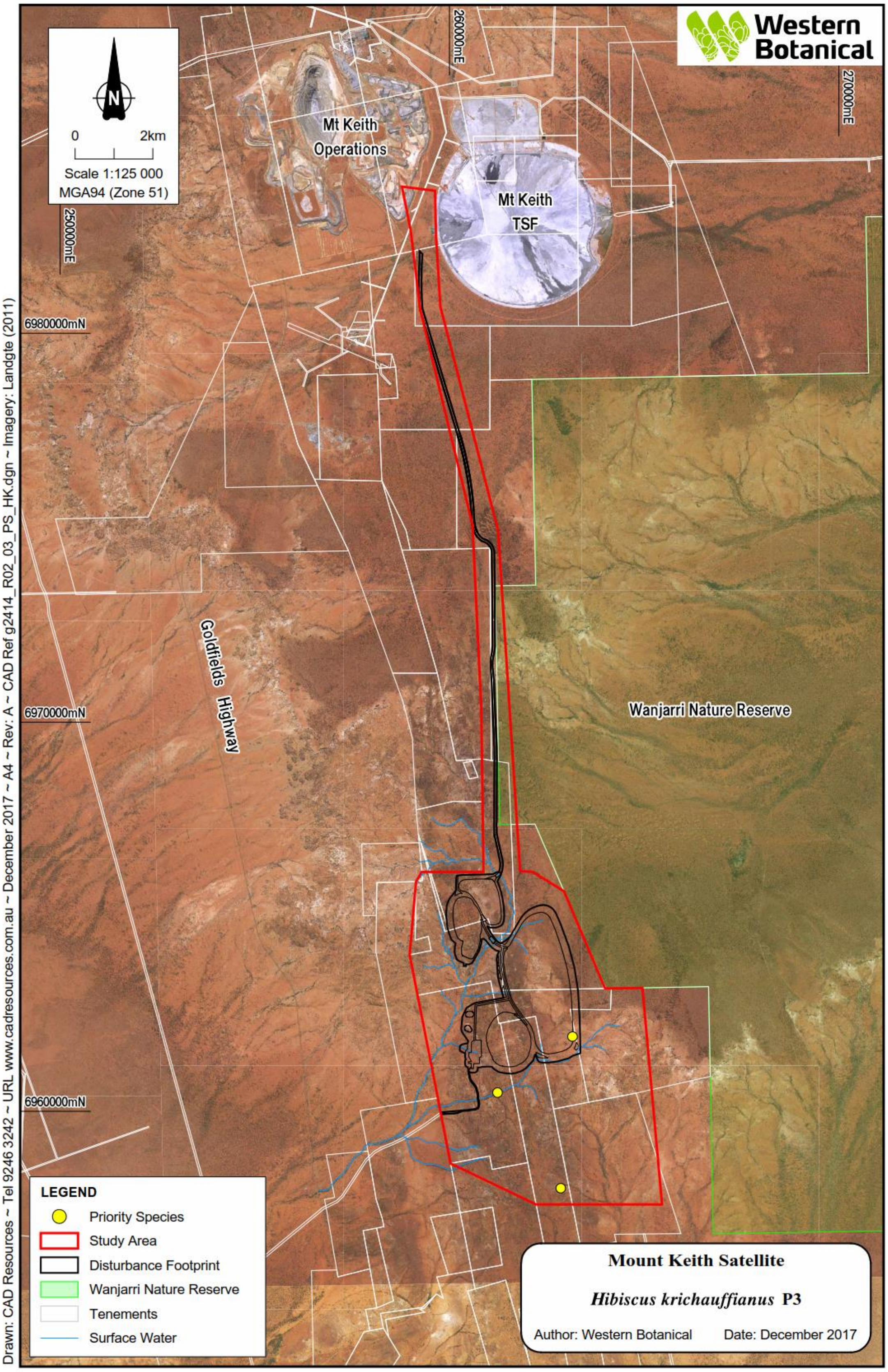


Figure 17 Mt Keith Satellite Proposal Known distribution of Hibiscus krichauffians

For the significant species previously described, clearing will directly impact on three of these species, for which the impacts are listed in Table 19.

Table 19 Summary of Direct Impacts on Species of Interest

Taxon	No of plants within Development Envelope	Proposed Impact	
		% of known local population	% of regional population
Acacia sp. East Murchison Basalt (G. Cockerton & J Warden WB39701)	280 [1]	70	<1
Acacia xanthocarpa flat phyllode form (G Cockerton & J Warden WB39702)	120 [2]	Not assessed	<1
Olearia sp. Sherwood Breakaways (A. Taylor 25552)	Not assessed[3]	<5	<1

1 Represents 70% of overall Acacia shrubland community which occurs on a phyllite shale outcrop over approximately 2.96ha on a site that lies on the margin between the Goliath pit area and the eastern WRL (Western Botanical, 2017).

2 Represents 30% of overall *Acacia* shrubland community, found growing with *Acacia* sp. East Murchison Basalt (Western Botanical, 2017)

3 Whilst the population has not been counted, the numbers are considered to very low, estimated to be less than 5% for the Olearia sp. known within the Study Area. This species exists in low numbers on all the breakaways in the region (Geoff Cockerton, personal communication, 15 November 2017.

The largest concentration of *Acacia* sp. East Murchison Basalt within the Development Envelope is this population (Figure 18). This is a newly recognised species which is found growing in two small sub-populations and as scattered individuals within the Study Area. The impact on the local population, as shown in Table 11 exceeds 70%. However in a regional context, this loss accounts for <1% of the regional population, as there are large populations known from numerous locations on phyllite shale outcrops and basalt hills between Menzies, Laverton and Yakabindie Station.

One population of the *A. xanthocarpa* flat phyllode located in the WRL footprint was estimated, and was considered to represent in the order of 50% of the local population. Significant numbers of this species are found on the Goliath orebody area, mixed with *A. xanthocarpa* terete phyllode form. The flat phyllode form 'species' is also found in scattered small populations outside the Development Envelope, with the issue of hybridity being a large problem in trying to determine population numbers with any accuracy. However in a regional context, impacts on this species through clearing for the Proposal are considered negligible due to numerous plants north of Leinster, north-west of Agnew and an unquantified population at the Booylgoo Range, west of Leinster/Agnew (G. Cockerton, personal communication, 15 November 2017).

Olearia sp. Sherwood Breakaways (A. Taylor 25552) is present on the Breakaway plateaux of the Sherwood Land System and will be impacted by the Proposal, in development of the transport corridor to NMK. *Olearia* sp. Sherwood Breakaways is known to be widespread (Figure 19) though always occurring in low numbers (Western Botanical, 2017).

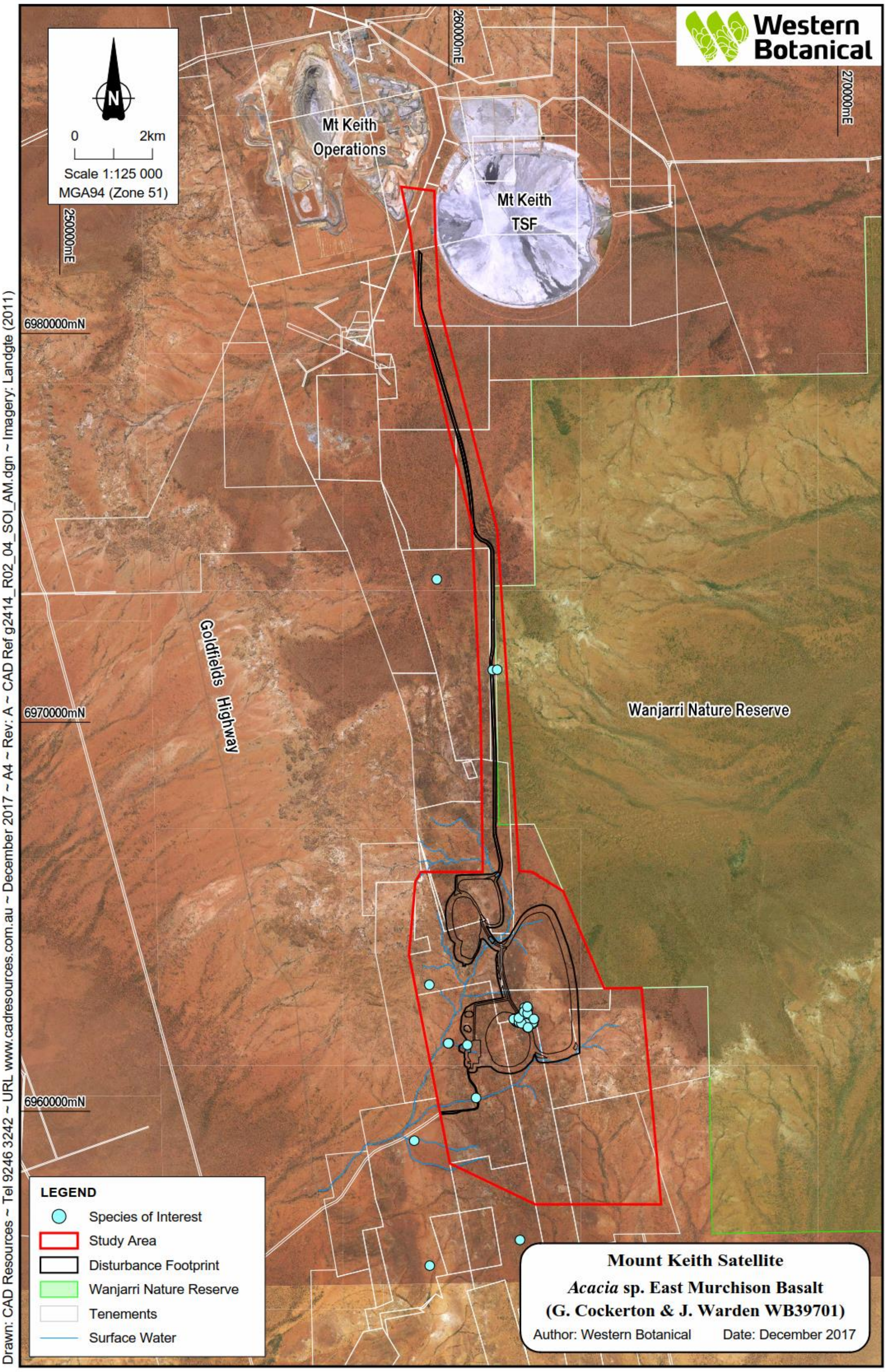


Figure 18 Mt Keith Satellite Proposal Populations of Acacia sp. East Murchsion Basalt (G Cockerton & J Warden WB39701)

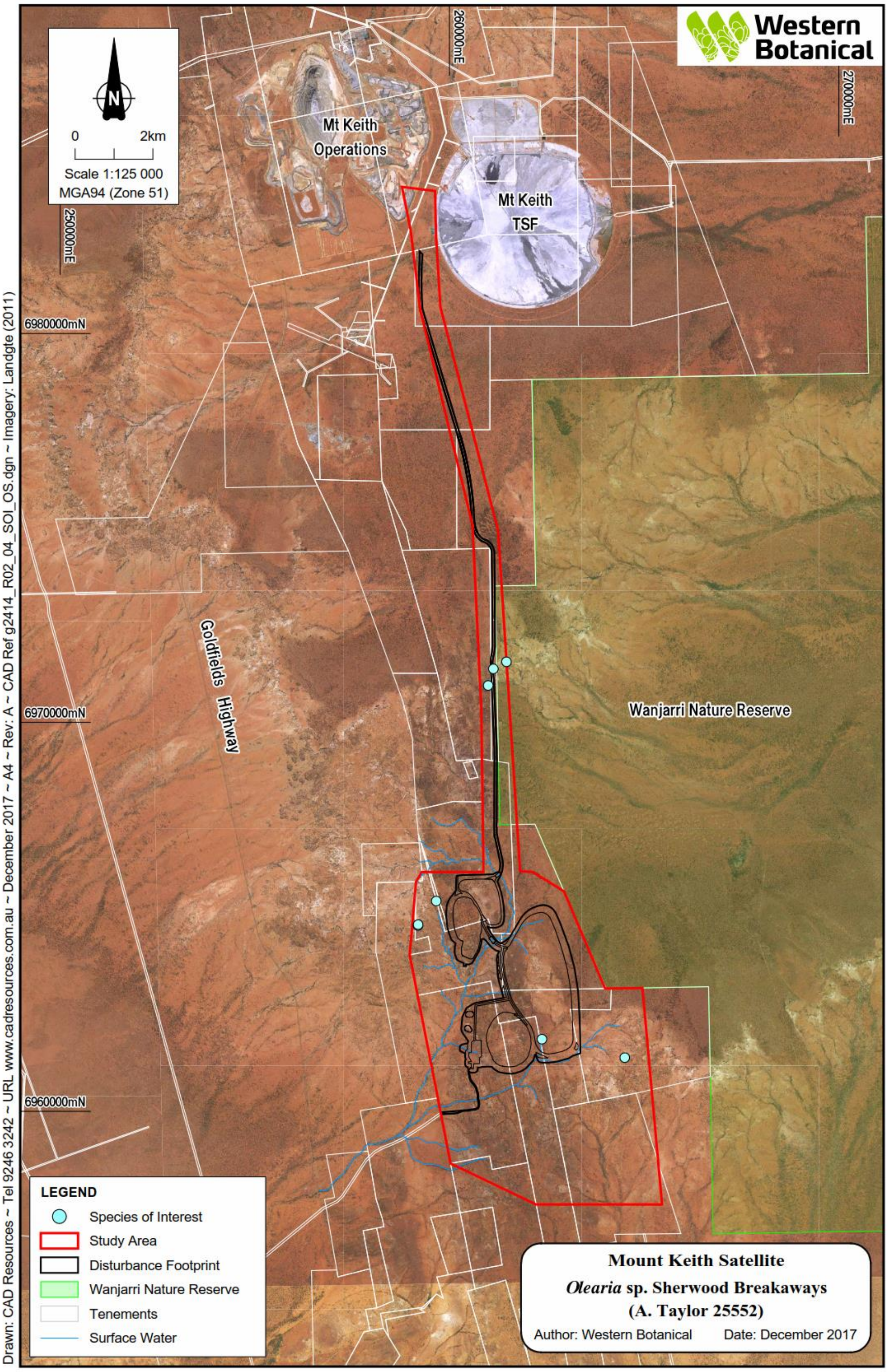


Figure 19 Mt Keith Satellite Proposal Populations of Olearia sp. Sherwood Breakaways (A.Taylor 25552)

Direct Impacts on Vegetation Associations

Thirty-eight Vegetation Associations and two Vegetation Association Complexes have been recognised within the Study Area. These have been grouped into six sub-units according to the dominating underlying geology/regolith which strongly influences the vegetation association species composition (refer to Table 20).

The impacts have been quantified and assessed as a proportion of the Study Area. Table 20 lists the direct impacts of the proposed clearing on the vegetation units, based on the results of improved mapping and re-classification of vegetation associations, relying on a greater level of detailed on-ground assessments. Each of the Vegetation Associations, other than SMS and GrMS, represent small proportions (less than 10%) of the area of the overall Study Area (5,422.09 ha). All Vegetation Associations are known from outside the Study Area.

Fourteen Vegetation Associations, and one Vegetation Association Complex of the Study Area will not be impacted at all by the proposed development of the mine voids, infrastructure areas and transport corridor. Thirteen Vegetation Associations, two Vegetation Association Complexes and one Vegetation Association Mosaic will be impacted to a degree less than 20%. Collectively these are considered low impacts and are not discussed further.

Five Vegetation Associations will be impacted at levels of between 20% and 50% of their area mapped within the Study Area. These are the EGPW (21.07%), USBS (29.90%), GHPS (37.67%), SSS (38.81%), and SIMS (39.29%). The EGPW, community is associated with the catchment of the upper reaches of Jones Creek and large areas of this are known outside the Study Area, in the vicinity of the McFarlane's Find abandoned prospect. The apparent restriction of this community in the local area is an artefact of the boundary of the Study Area excluding the region inclusive of McFarlane's Find, north-west of the Study Area. No species with conservation significance are known within this community within the Study Area. However, west of the Study Area, *Cratystylis centralis sens. lat.* P3 is known to be strongly associated with the EGPW Community (Western Botanical, 2017).

The USBS Community comprises 1.7% of the Study Area and is characterised by occasional *Acacia oswaldii* (narrow leaf form) and *Hakea preissii* emergent over a broad range of low annual and perennial halophytic herbs. Direct impact to the USBS community is calculated to be 35.15% of its mapped occurrence within the Development Envelope and 29.90% of its mapped occurrence within the broader Study Area. No information is available on the regional context of the USBS Community, as it has not been encountered at either Leinster or Mt Keith. No species with conservation significance are known within this community.

The GHPS community is strongly associated with mildly saline carbonate influenced soil and supports *Eremophila pantonii* and *Hakea leucoptera* subsp. *sericipes* Shrublands with a chenopod (*Maireana* spp.) understorey. It is only known from the region between Leinster and Mt Keith and seems to be strongly associated with soils of the Perseverance Fault Line. GHPS is almost always associated with the SSS community. No species with conservation significance are known within this community.

The SSS Community is characterised as a mid shrubland of *Senna* species with occasional emergent *Hakea preissii* and *Hakea leucoptera* subsp. *sericipes*. It is associated with low stony rises and lies upslope of USBS and is often adjacent to GHPS communities. No species with conservation significance are known within this community.

The SIMS Community comprises 7.6% of the Study Area and is characterised by Mulga (*Acacia aneura* and its allies) Shrublands with very little understorey on low, rounded lateritic hills that may include minor chert, quartz and tertiary laterite – ferricrete outcrop. The small and limited outcrops of limonitic material were the focus of the Meissner and Wright (2010) Surveys of vegetation of banded ironstone formations of the Perseverance Greenstone Belt, nine sites of which lie within the Study Area. Impacts to SIMS are 39.29% of its mapped occurrence within the Study Area. While SIMS is also mapped extensively at Mt Keith and Leinster (Landcare Services, 1997a and 1997b), due to changes in species composition of the understorey, these communities are considered not directly comparable and were separated in the first major branches of the statistical analysis undertaken and presented in Western Botanical (2016). However, the SIMS communities at Mt Keith, the Proposal, and Leinster contain many species in common, including a range of Mulga varieties, *Acacia pruinocarpa*, *Scaevola spinescens* (narrow leaf, spiny form), *Eremophila jucunda* subsp. *jucunda*, *Eremophila latrobei* forms, *Eremophila* sp. Leinster (R.J. Cranfield 6767) that is within the *Eremophila pungens* P4 complex, *Senna* sp. Meekatharra (E. Bailey 1-19) and *Harnieria kempeana* var. *muelleri* as a minor inclusion.

The MMS Community is characterised tall Mulga (*Acacia aneura sens. lat.*and related species) over a sparse mid storey of *Sida ectogama, Ptilotus obovatus* (upright form) and a consistently dominant understorey of the halophyte

Maireana triptera. The upper stratum is characteristically open tall shrubland of Mulgas *Acacia incurvaneura*, *A. pteraneura* and *A. aneura* (PFC 15-20%), occasionally with scattered *Hakea preissii*. The midstory is quite variable, but usually characterized by scattered mid shrubs of *Scaevola spinescens, Acacia tetragonophylla, Ptilotus obovatus, Senna* sp. Meekatharra (E. Bailey 1-26), *Rhagodia drummondii*, *Enchylaena lanata* (PFC 5-15%). The lower stratum of MMS is dominated by chenopod species, *Maireana georgei, M. triptera, Sclerolaena eriacantha,* and *Aristida contorta* and *Enneapogon caerulescens* (PFC 5-30%), with regular presence of *Ptilotus nobilis, P. helipteroides, Cheilanthes sieberi, Sida* sp. dark green fruits (S. van Leeuwen 2260), *Solanum lasiophyllum* and *Maireana tomentosa*." It forms the some of the lower colluvial slopes downslope of the SIMS community within the Bevon Land System. It may also represent a broad ecotone between the SIMS and USBS communities.

The combination of Mulga trees over *Maireana triptera* is known outside the Study Area, with small areas known near Leinster, at the southern end of the Mt Keith – Perseverance lineament though its extent there and cumulative impacts on this Vegetation Association have not been assessed. It may also be present elsewhere within the Violet Range PEC though this has not been mapped.

The MMS community is impacted to 60.48% of its mapped proportions within the Study Area. Minimization of impacts to the MMS Vegetation Association in development of the MKS proposal is difficult as it occupies the lower slopes of the Six Mile orebody area and is mapped on the periphery. Development of the Six Mile orebody and the adjacent wastedump to the north-east unavoidably impacts on this community. The extent of the MMS communities that remain unimpacted within the Study Area is 130.43 ha (39.52% of its mapped occurrence within the Study Area).The MMS community is also known outside the Study Area, near the Leinster nickel mine, at the southern end of the Mt Keith –Perseverance lineament. No species with conservation significance are known within this community.

The HMPS-Thoma community is found in two small areas in the eastern part of the Study Area, within the proposed wastedump footprints and will be impacted to 100% of its local occurrence. It represents a floristic association typical of the broader HPMS community but differs in occurring on low rises, having a shallow sandy mantle present and supporting populations of *Acacia thoma*, which is known at four locations within the Study Area from Leinster, within the Wanjarri Nature Reserve and the southern and central Pilbara bioregion. Whilst it is uncommon in the landscape in the region between Leinster and Mt Keith it is sufficiently widespread and not of conservation significance.

Impacts to Jones Creek vegetation, represented by the DRES community are 1.67 ha, or 3.3% of its occurrence within the Disturbance Footprint. DRES are narrow to broad incised ephemeral watercourse that usually have a sandy bottom over the exposed bedrock that support *Eucalyptus camaldulensis* as a major feature. The upper stratum is characteristically scattered *Eucalyptus camaldulensis* subsp. *obtusa* trees which occur along the incised channel. The mid story of mid to tall shrubs occur primarily along the banks of the incised drainage lines, including *Acacia burkittii*, *A. tetragonophylla*, *A. aptaneura* and *Pimelea microcephala* subsp. *microcephala*. The lower stratum of DRES is limited to the raised sandbanks within the drainage lines and the banks, where it is dominated by the grass species *Themeda triandra*, *Cymbopogon ambiguus*, *Aristida contorta* and occasional *Aristida jerichoensis* var. *subspinulifera* P3. The mobile coarse sandy beds of the deeply incised drainage channels are usually bare of vegetation. Other commonly occurring species include *Duperreya commixta*, *Senna artemisioides* subsp. *X artemisioides*, *Acacia quadrimarginea sens. str*., *Ptilotus obovatus*, *Sida ectogama*, *Abutilon cryptopetalum*, *Eremophila exilifolia* and *Pluchea dentex*. The priority species *Hemigenia exilis* (P4) has been recorded within this vegetation community, along with the weed species *Bidens bipinnata*.

The HPMS-Thoma community is found in two small areas in the eastern part of the Study Area, within the Development Envelope and 100% of its local occurrence is proposed to be impacted. It represents a floristic association typical of the broader HPMS community but differs in occurring on low rises, having a shallow sandy mantle present and supporting populations of *Acacia thoma*. *Acacia thoma* is known at four locations within the Study Area, from Leinster, within the Wanjarri Nature Reserve, and is more commonly recorded in the central Pilbara bioregion. The HPMS-Thoma community is also represented (though not mapped) within the Wanjarri Nature Reserve east of the haul road component of the Study Area. The impact to this community does not represent a significant impact in a regional context.

Table 20 Direct impacts on vegetation associations

Landform / Geology	Vegetation Code	Description	Study Area		Development Envelope		Disturbance Footprint	
			ha	% of Study Area	ha	Impact as % of Study Area	ha	Impact as % of Study Area
Archaean granite geology	BrCP - TectS	Breakaway Chenopod Plain Complex - Tecticornia Shrubland (component of the BrCP Complex)	0.58	0.01%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrCP-FRAN	Breakaway Chenopod Plain Complex - Frankenia shrubland (component of the BrCP Complex)	8.46	0.16%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrGP	Breakaway Grassy Plain	18.70	0.34%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrX	Archaean Granite Breakaway	7.08	0.13%	0.00	0.00%	0.00	0.00%
Archaean granite geology	BrX-FOL	Archaean Granite Breakaway Footslope	15.71	0.29%	0.00	0.00%	0.00	0.00%
Archaean granite geology	GrEx	Granite, Exfoliating granite outcrops	62.40	1.15%	0.00	0.00%	0.00	0.00%
Archaean granite geology	GrMS - BRX Complex	Complex of Granite Mulga Shrubland - Granite Breakaway Plateaux	48.30	0.89%	0.00	0.00%	0.00	0.00%
Archaean granite geology	SGRS	Sandy Granitic Mulga Shrubland	5.37	0.10%	0.00	0.00%	0.00	0.00%

Landform / Geology	Vegetation Code	Description	Study Area		Development Envelope		Disturbance Footprint	
			ha	% of Study Area	ha	Impact as % of Study Area	ha	Impact as % of Study Area
Basalt geology (Fresh Rock)	BaAbS	Basalt, Acacia burkittii Shrubland (component of the BaMAS complex)	11.93	0.22%	0.00	0.00%	0.00	0.00%
Basalt geology (Fresh Rock)	BaCdS	Basalt, Calytrix desolata low Shrubland	22.72	0.42%	0.00	0.00%	0.00	0.00%
Colluvial and Alluvial landforms	HMCS	Mulga Shrubland with scattered low Chenopod Shrubs	24.00	0.44%	0.00	0.00%	0.00	0.00%
Colluvial and Alluvial landforms	MPS	Maireana pyramidata Shrubland	6.83	0.13%	0.00	0.00%	0.00	0.00%
Sandplain Landforms	MUWA	Mulga - Wanderrie Grassland	2.75	0.05%	0.00	0.00%	0.00	0.00%
Sandplain Landforms	SAMA	Sandplain, Mallee, Acacia species Spinifex Shrubland	13.27	0.24%	0.00	0.00%	0.00	0.00%
Sandplain Landforms	SAWS	Sandplain, Acacia species Spinifex Shrubland	11.92	0.22%	0.00	0.00%	0.00	0.00%
Basalt geology (Fresh Rock)	BaMAS	Basalt, mixed Acacia species Shrubland Complex	182.92	3.37%	0.33	0.18%	0.16	0.09%
Basalt geology (Fresh Rock)	BaAdS	Basalt, Acacia doreta long phyllode form Shrubland (component of the BaMAS complex)	19.38	0.36%	0.86	4.46%	0.25	1.28%
Archaean granite geology	BrCP	Breakaway Chenopod Plain Complex	12.23	0.23%	0.41	3.36%	0.27	2.24%

Landform / Geology	Vegetation Code	Description	Study Area		Development Envelope		Disturbance Footprint	
			ha	% of Study Area	ha	Impact as % of Study Area	ha	Impact as % of Study Area
Colluvial and Alluvial landforms	DRES	Drainage Line Eucalypt Woodland	50.46	0.93%	3.79	7.51%	1.67	3.30%
Archaean granite geology	GrMS	Granitic Mulga Shrubland	990.02	18.26%	35.19	3.55%	33.46	3.38%
Sandplain Landforms	SAMU	Sandplain Mulga Spinifex Shrubland	172.04	3.17%	16.16	9.39%	8.22	4.78%
Basalt geology (Fresh Rock)	BaAxS	Basalt, Acacia aff. xanthocarpa Shrubland (component of the BaMAS complex)	83.24	1.54%	9.73	11.69%	4.46	5.36%
Colluvial and Alluvial landforms	GRMU	Groved Mulga Woodland	65.21	1.20%	5.51	8.45%	3.56	5.46%
Colluvial and Alluvial landforms	DRMS	Drainage Line Mulga Shrubland	381.54	7.04%	37.67	9.87%	22.41	5.87%
Limonitic Landforms	SILS	Stony Ironstone Low Shrubland	27.17	0.50%	2.37	8.72%	1.82	6.69%
Archaean granite geology	BrX-P	Archaean granite geology	30.79	0.57%	2.85	9.27%	2.12	6.89%
Sandplain Landforms	WABS - SAMU Mosaic Complex	Mosaic of Wanderrie Bank Grassy Shrublands / Sandplain Mulga Spinifex Shrubland	153.89	2.84%	20.57	13.36%	14.65	9.52%
Archaean granite geology	SAES	Stony Acacia Eremophila Shrubland	484.25	8.93%	80.76	16.68%	55.76	11.51%
Sandplain Landforms	WABS	Wanderrie Bank Grassy Shrublands	182.23	3.36%	36.22	19.88%	27.19	14.92%
Colluvial and Alluvial landforms	SMS	Stony Mulga Shrubland	763.84	14.09%	186.25	24.38%	116.69	15.28%

Landform / Geology	Vegetation Code	Description	Study Area		Development Envelope		Disturbance Footprint	
			ha	% of Study Area	ha	Impact as % of Study Area	ha	Impact as % of Study Area
Colluvial and Alluvial landforms	HPMS	Hardpan Mulga Shrubland	323.35	5.96%	102.73	31.77%	50.75	15.69%
Carbonate Soils, derived from Weathered Basalt	EGPW	Weathered Basalt, Eucalyptus gypsophila - Eremophila pantonii Woodland	11.92	0.22%	5.16	43.26%	2.51	21.07%
Limonitic Landforms	USBS	Upland Small Bluebush Shrubland	92.93	1.71%	32.67	35.15%	27.78	29.90%
Carbonate Soils, derived from Weathered Basalt	GHPS	Weathered Basalt, Hakea leucoptera subsp. sericipes - Eremophila pantonii Shrubland	233.19	4.30%	107.44	46.07%	87.84	37.67%
Carbonate Soils, derived from Weathered Basalt	SSS	Stony Senna Shrubland	127.71	2.36%	54.64	42.79%	49.56	38.81%
Limonitic Landforms	SIMS	Stony Ironstone Mulga Shrubland	412.28	7.60%	254.86	61.82%	162.00	39.29%
Colluvial and Alluvial landforms	MMS	Mulga over Maireana triptera Shrubland	329.99	6.09%	259.82	78.74%	199.56	60.48%
Colluvial and Alluvial landforms	HPMS THOMA	Hardpan Mulga Shrubland with Acacia thoma co-dominant	3.02	0.06%	3.02	100.00%	3.02	100.00%
Ponded Water	Ponded Water	Ponded Water	1.50	0.03%	0.00	0.00%	0.00	0.00%
Disturbed	Disturbed	Disturbed	27.00	0.50%	0.00	0.00%	0.00	0.00%

Direct impacts on Violet Range Priority Ecological Community

The Study Area occupies 3,248.5 ha (16.87%) of the Violet Range (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation) P1 PEC. Table 21 summarises the direct impacts of the Proposal on this PEC.

Table 21 Direct impacts on Violet Range Priority Ecological Community

PEC Area (ha)	Study Area (ha)		Development Envelope		Disturbance Footprint	
	ha	% of total	ha	% of total	ha	% of total
19256.2	3248.5	16.87	1009.4	5.24	724.4	3.76

Minimal historical impacts to the Violet Ranges PEC have occurred to date with clearing for pastoral tracks and fences as well as historical mining activities at the abandoned Bellevue site on the north-shore of Lake Miranda being the major contributors. As shown in Table 21, the current worst case scenario of direct impact on the currently mapped Violet Ranges PEC is 5.24% (Development Envelope) with actual impact (Disturbance footprint) to be 3.76%.

The majority of the geology within the Violet Ranges PEC is basalt and gabbro and some granite with only minor Banded Ironstone Formation (BIF), chert and quartz outcrops present with associated tertiary laterite capping present. In the vicinity of the Study Area, the vegetation associations associated with the Mt Keith Perseverance fault line are constrained within the boundaries of the Violet Ranges PEC. However, while narrow in an east-west orientation, these landforms extend beyond the limits of the PEC as currently mapped. These additional areas extend in a discontinuous fashion both northward (north of NMK) and southward (to the Leinster nickel mine) directions for an overall inclusive length of approximately 82 km. The currently mapped Violet Ranges PEC represents around 40 % of this overall range. (Western Botanical, 2017).

Figure 20 shows the potential extent of the Violet Range PEC based on an assessment of:

- known Violet Range PEC extent (DBCA defined);
- areas of vegetation associations identified during the surveys outside known extent; and
- areas with similar landform and geology to components of the Violet Range PEC (as a key driver to the PEC occurrence).

The areas of potential similarity to the Violet Range PEC occupy an area of approximately 18288 ha, an area almost equivalent to that of the currently mapped PEC. If the expanded area was to be considered as representing similar vegetation associations aligned with the intent of the Violet Ranges PEC, then the proportional impact of the Proposal on the PEC would be approximately halved to around 2% (not including cumulative impacts of Leinster and NMK).

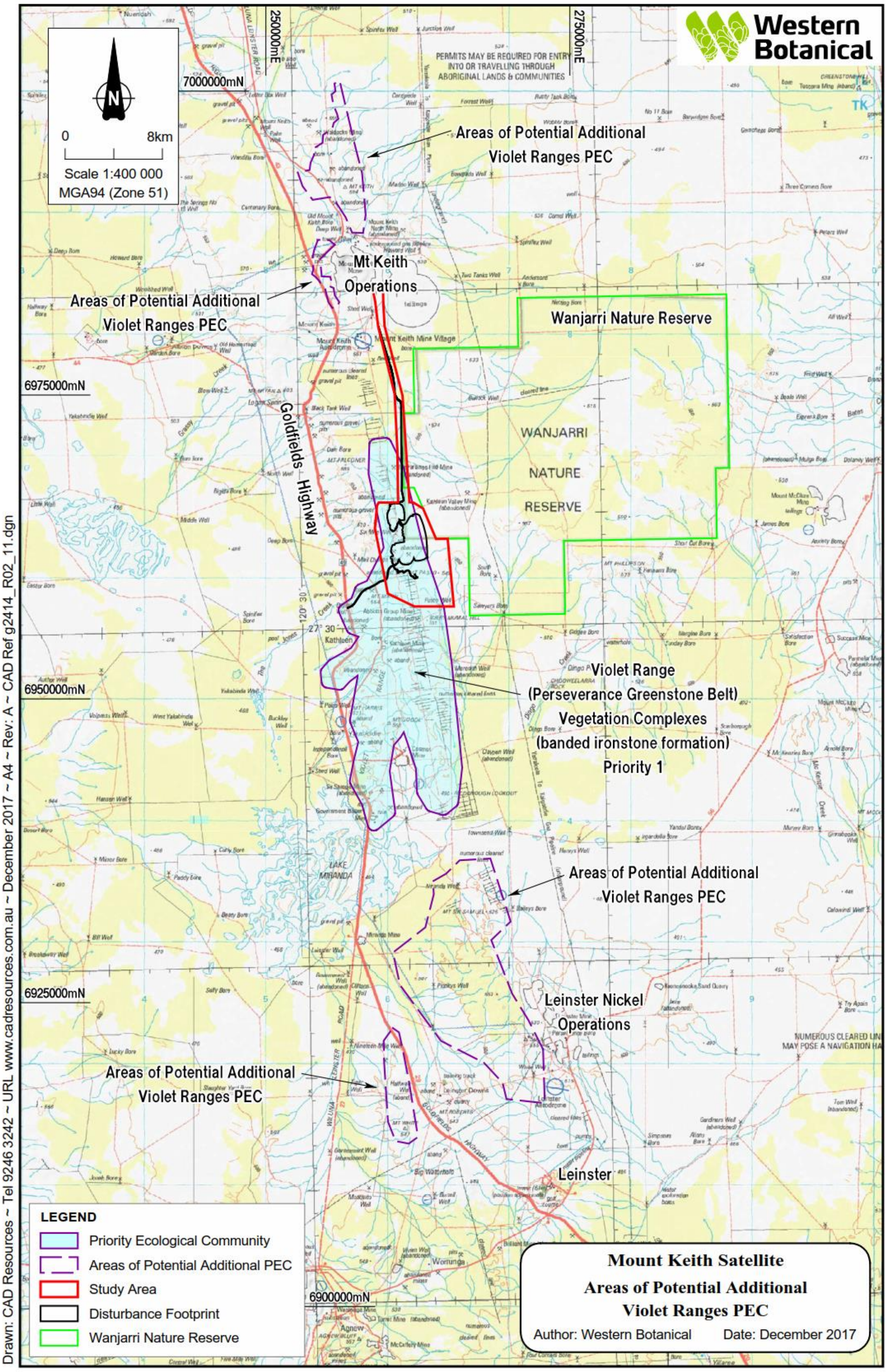


Figure 20 Violet Range PEC current boundary (dark red polygon) and areas of similar geology, landform and vegetation in the region (pink polygon)

Assessment of potential indirect impacts

Indirect impacts are discussed below. These impacts have the potential to be cumulative where one impact type would enable another to occur, leading to a greater adverse outcome.

Habitat fragmentation

There is the potential for the viability of vegetation communities, flora and associated fauna habitat remaining after land clearing to be reduced by fragmentation, where once large continuous blocks of habitat are disrupted. This may result in changes in genetic flow, colonisation and recruitment that may impede the functionality of a species or community, particularly for populations at the limits of their distribution.

The flora of the breakaway landscape is naturally sparse with large gaps between plants and groups of plants of a range of species. Species tend to flower rapidly after sufficient rainfall, often following thunderstorm or cyclonic rainfall events. Hibbertia, and the majority of other species found on the breakaways, are insect pollinated. The specific pollinators of Hibbertia sp. are expected to include native bees, moths, wasps, flies, and beetles. Gaps in populations of insect pollinated species with commensurate flowering phenology may result in barriers to gene flow amongst disjunct populations of these species.

The impact on Priority species has been used as the indicator in the assessment of impacts from fragmentation for this Proposal. The potential for fragmentation impacts has been considered to occur where plants exist immediately adjacent to the Proposal area and may be disrupted. The taxa with conservation significance on which fragmentation of the local population is expected, through unavoidable clearing loss and for which this risk exists are:

***Hybanthus floribundus* subsp. *chloroxanthus* P3 (14.35% impact on local and regional population)**

Populations of *Hybanthus floribundus* subsp. *chloroxanthus* are naturally disjunct, occurring within small, isolated remnants of suitable habitat. On a regional scale, four populations of the species are known (NMK to MKS, Leinster, Weebo Station and Murrin Murrin). On a local scale between NMK and MKS, this population is further defined in to four sub-populations, occurring in a north-south alignment on the western margin of the Perseverance fault line, Figure 15. These demonstrate naturally occurring disjunctions of between 5 and 12 km between sub-populations. The taking of part of a sub-population, that laying within the Six Mile orebody area, has minimal impact on further fragmentation of the population in this area and is considered to have minor local and no regional consequence with respect to fragmentation of populations.

This species is typically found in rocky areas, creek banks and along drainage lines. The sub-population to be disturbed by clearing is largely located within the Six Mile Well pit boundary. A large portion of this sub-population that exists outside the proposed pit within an ephemeral drainage line will remain undisturbed and will be intact (Figure 21). Here, the species occupies a small niche on the margins of narrowly incised Mulga dominated ephemeral drainage line (DRMS Community) which drains southward from approximately 6975700 mS. It receives run-on from the adjacent granitoid landscape to the west and from the Six Mile orebody area on the eastern side of the drainage line. Development of the MKS proposal will unavoidably reduce the overall catchment area and therefore overall volume of surface water run-on into this minor creekline. It is assumed that the *Hybanthus floribundus* subsp. *chloroxanthus* plants here derive their moisture from within the fractured rocks on the margins of the drainage line and that this moisture is replenished during surface flow events, particularly when free water is resident in the ephemeral drainage line for extended periods. This would normally be following heavy rainfall events. The catchment area supplying the residual *Hybanthus floribundus* subsp. *chloroxanthus* population within the ephemeral drainage line is approximately 191.97 ha in area; with the majority of this occurring on the northern and western sides of the drainage line. Of the eastern portion of this catchment, 23.52 ha is proposed to be taken by development of the Six Mile pit, representing 12.25% of the overall catchment for this species in this area.

***Verticordia jamiesonii* P3 (5.26% of local population, with regional impact not assessed)**

This species is found on the plateaux of weathered Archaean granite breakaways that traverse the Proposal area and extend into the Wanjarri Nature Reserve. A small population of this species (63 plants) occurs on the haul road alignment and will be impacted. It is possible that some plants may remain following completion of clearing and road construction with likelihood of fragmenting this population, however the assessment of direct clearing impacts has assumed all plants will be lost. A much larger population of approximately 500 plants occurs on the low breakaways within the south-east portion of the Study Area and will remain undisturbed and additional naturally disjunct populations occur in the nearby Wanjarri Nature Reserve (Figure 16). On this basis the potential impacts both locally and regionally are considered minor.

***Hibbertia* sp. Sherwood Breakaways P2 (2.08% of local and regional population)**

Two populations of *Hibbertia* sp. Sherwood Breakaways are recognised (**Figure 22**), separated due to cadastral boundaries (Population 1 on Wanjarri Nature Reserve, WNR, vs. Population 2 on Yakabindie Station). Within the two populations, sub-populations of *Hibbertia* sp. Sherwood Breakaways are naturally disjunct, separated by gaps of 200m to 700m, reflecting the dissection of the landscape and the disjunctions in suitable habitat supporting the species. Population 1 within WNR demonstrates disjunctions of up to 250m between groups of plants but has been mapped as one population as the habitat likely to support the species is reasonably continuous. Population 2 on Yakabindie Station can be arbitrarily mapped into six sub-populations where disjunctions in occurrence of plants of over 200m occur, or where discontinuity of habitat likely to support the species exists.

There are significant numbers of *Hibbertia* sp. Sherwood Breakaways occurring on either side of the proposed haul road alignment. To the east, within the WNR, the estimated population of 1,428 plants has a spatial disjunction from the proposed haul road and Population 2 within Yakabindie Station. The closest point of the WNR population to the proposed haul road alignment is 340m. This populations lies east of a drainage divide and is therefore considered secure. The six sub-populations on Yakabindie Station each support hundreds to thousands of plants in most cases, though one sub-population consists of one isolated plant. Development of the haul road alignment will cut-off the eastern edge of the north-eastern sub-population (sub-population 2.1) supporting approximately 428 plants.

Given the natural disjunctions between the sub-populations of the species, the issue of fragmentation of the population on a local scale arising from development of the proposed haul road may only affect the 428 plants on the eastern side of the haul road alignment within Population 2.1. The potential disjunction here reflects natural disjunctions already observed within the existing population.

***Eremophila* sp. long pedicels (G. Cockerton 1975)**

A small population of *Eremophila* sp. long pedicels (G. Cockerton 1975) will be fragmented by the haul road. An estimated 20 plants of *Eremophila* sp. long pedicels lie within the proposed haul road alignment to Mt Keith and will be disturbed. The proposed disturbance represents 0.04% of the known population. This population covers some 70 ha and would mostly be bisected by the haul road.

An estimate of the population at Mt Keith was made by Western Botanical by accumulating occurrence data generated over many years, resulting in a local population of around 37,533 plants. The regional population of *Eremophila* sp. long pedicels has been estimated at a minimum of 50,000 plants in 4 sub-populations (Western Botanical).

Potential to spread or introduce weeds

Weeds can compete for resources with native flora and disrupt ecological function. When intact populations of native plants are fragmented, or areas disturbed or adjacent to ground disturbance, the risk of weed incursion increases. Weed numbers can increase by:

- windblown seed from existing populations spreading to adjoining areas;
- weed seed in existing seed banks being spread during soil movement or disturbance; and
- weed seed entering the site through contaminated vehicles, earthmoving equipment or construction materials.

Weed populations within the Study Area are found in small, isolated populations with low numbers of individuals present. Three of the species of weeds have the potential to be highly invasive (Ruby Dock, Buffel Grass and Birdwood Grass). Excluding intentional introduction through pastoral activities, the nearest significant weed invasion sources are (i) the Goldfields Highway and (ii) the Mt Keith minesite. The existing weed occurrences can be managed through combined (i) targeted weed control and / or removal and (ii) selected excavation and burial of surface soils likely containing weed seed banks. Weed hygiene for all machinery entering the MKS site, including weed control at both the Mt Keith minesite and the Goldfields Highway intersection will assist in minimizing any weed ingress to the site on vehicles and machinery entering the MKS site.

Weeds impacts may be cumulative in response to other impacts to native vegetation such that they may excasserbate the decline or change in native vegetation composition and disrupt ecological processes. Such impacts, particular where resultant in changed species composition and fuel load, may alter the potential fire regime.

A wide range of species are prevalent at the Mt Keith Mine as observed by Western Botanical in their May and October/November surveys. Given that Proposal and the Mt Keith mine will be linked via a haul road, there is an increased potential for spread of weeds into the Proposal area through vehicle movement, both during construction and operation.

Mt Keith Mine currently operates a targeted biannual weed inspection and spraying regime to coincide with post rainfall periods. A similar approach to weed management will be implemented to minimise the risk of spread of weeds, both during construction and operation.

Altered fire regime

Bushfire potential depends on many factors, with the previous wet season being the primary factor. The volume, location and timing of rainfall are critically important for determining fuel volumes and growth. In some types of vegetation such as grasslands and spinifex shrublands, fire is a major determining factor in affecting species composition. It can cause disturbance to vegetation condition but can also be required for regeneration for some species.

The Proposal is located within the Murchison Bioregion, which as an arid climate and rainfall can occur at any time of the year. Summers are hot and dry with infrequent, high intensity seasonal thunderstorms and occasional cyclonic events (Section 2.4).

An assessment of the North Australian Fire Information database for the Study Area indicates low fire frequency in this part of the Northern Goldfields (Figure 23). The most recent (2014 to 2016) and extensive fires have occurred in the eastern portion of the Wanjarri Nature Reserve. This is consistent with observations from environmental personnel at NMK that local fires occur infrequently, with lightning strike fires occurring in the order of once per year (A.Gleeson, 2017 pers.comms. 17 November).

The likelihood of fire in the Proposal area is naturally low due to arid climate and low natural fire frequency. Mining activities have the potential to introduce sources of ignition through hot work and other activities. However, these can be actively managed by fire and emergency management procedures currently used by NiW at NMK. The introduction of additional mining activities, including the clearing of native vegetation, is unlikely to directly increase or alter the existing fire regime within both the local and regional context.

The majority of the Proposal operational areas and areas of direct clearing are within non-grassy habitat units. The sandplain to the east of the waste rock dumps and through which part of the haul road traverses between MKS and NMK are the only areas which would naturally carry a fire due to existing grassy (Spinifex) understorey. The presence of existing weed species in small, isolated patches does not alter or enhance the existing fire regime. However the introduction of weeds such as buffel grass may alter and increase the fuel load in those areas. Infestations along water courses and other areas introduce a risk of altered fire regime. Effective management of weeds will ensure the fire potential is not exacerbated.

Impacts to adjacent native vegetation of Wanjarri Nature Reserve

The Wanjarri Nature Reserve is contiguous with an approximately 6.4km length of the eastern margin of the haul road footprint (Figure 3). Whilst there will be no direct impact on the vegetation of the Reserve, there is the potential for indirect impacts such as dust from mining activities resulting in foliar dust deposition and loss of vegetation condition. Accumulation of dust particulates on leaf surfaces can occur as a result of exposure to dust, resulting in a reduced ability for the plant to photosynthesise and transpire, causing decline in health and possible eventual plant death if not alleviated.

Dust will be generated during construction when clearing of vegetation and topsoil occurs. Dust will also be generated during the operations phase through progressive clearing, vehicle movements on roads and tracks, mining and movement of ore and overburden and rehabilitation activities such as spreading of overburden, topsoil and vegetative matter.

Air dispersion modelling has been undertaken to assess the potential impacts of dust emissions on ambient air quality and potential deposition on sensitive receptors including vegetation (Appendix G). The assessment focussed on fugitive emissions from major dust generating activities such as drill and blast, mining, material handling, stockpiling, reclaiming, vehicle movements on unsealed surfaces, transport of ore for processing and wind erosion of unsealed surfaces and stockpiles (Ramboll, 2017).

The modelling took into consideration the location of the proposal in an arid environment, where background concentrations of dust deposition are likely to be elevated. Natural vegetation in the region is considered likely to have developed a degree of tolerance to elevated levels of relatively inert dust. Most studies of the effects of mineral dusts on vegetation have focussed on dusts that have chemical effects (e.g. cement dust) or where dust loads exceed 7 g/m2. A study by Doley and Rossato (2010) on the impacts of particulate deposition on photosynthesis in cotton leaves and canopies, indicated that many plant species have similar ranges of values for the photosynthetic parameters used in assessing the impacts on cotton. It is possible to use these as general estimates for modelling the impacts of particulate deposition and therefore the risks associated with dust generating activities. The study completed by Doley and Rossato (2010) indicated that at deposition levels of approximately 0.3 g/m2/d the estimated reductions in canopy photosynthesis of cotton plants would be less than 7% with a <1% decrease in productivity (Ramboll, 2017).

A number of sensitive receptor locations were selected inside and outside of the Wanjarri Nature Reserve, for predicting dust deposition rates. (Figure 24).

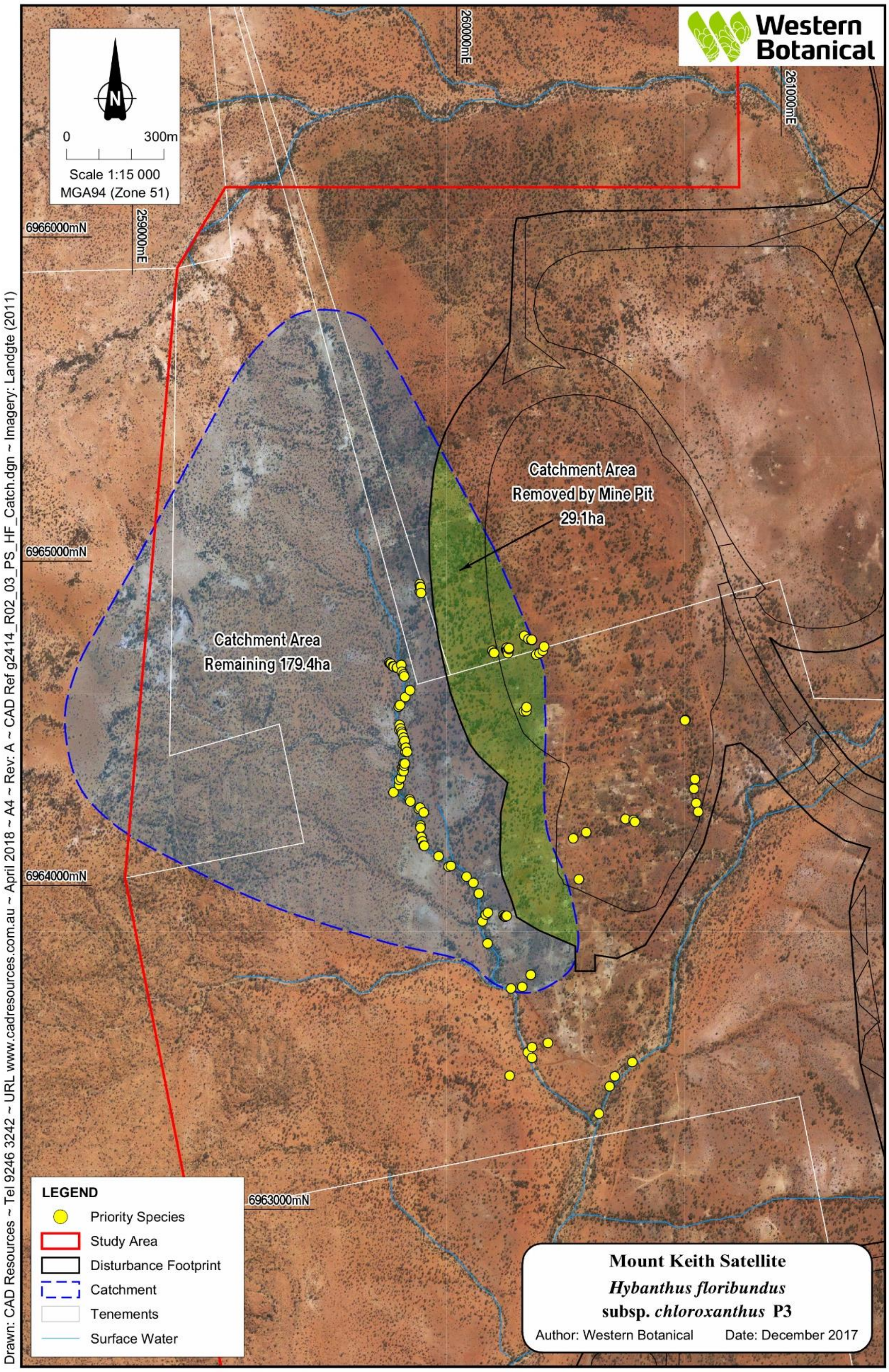


Figure 21 ***Hybanthus floribundus*** **subsp.** ***chloroxanthus*** **P3 catchment setting**

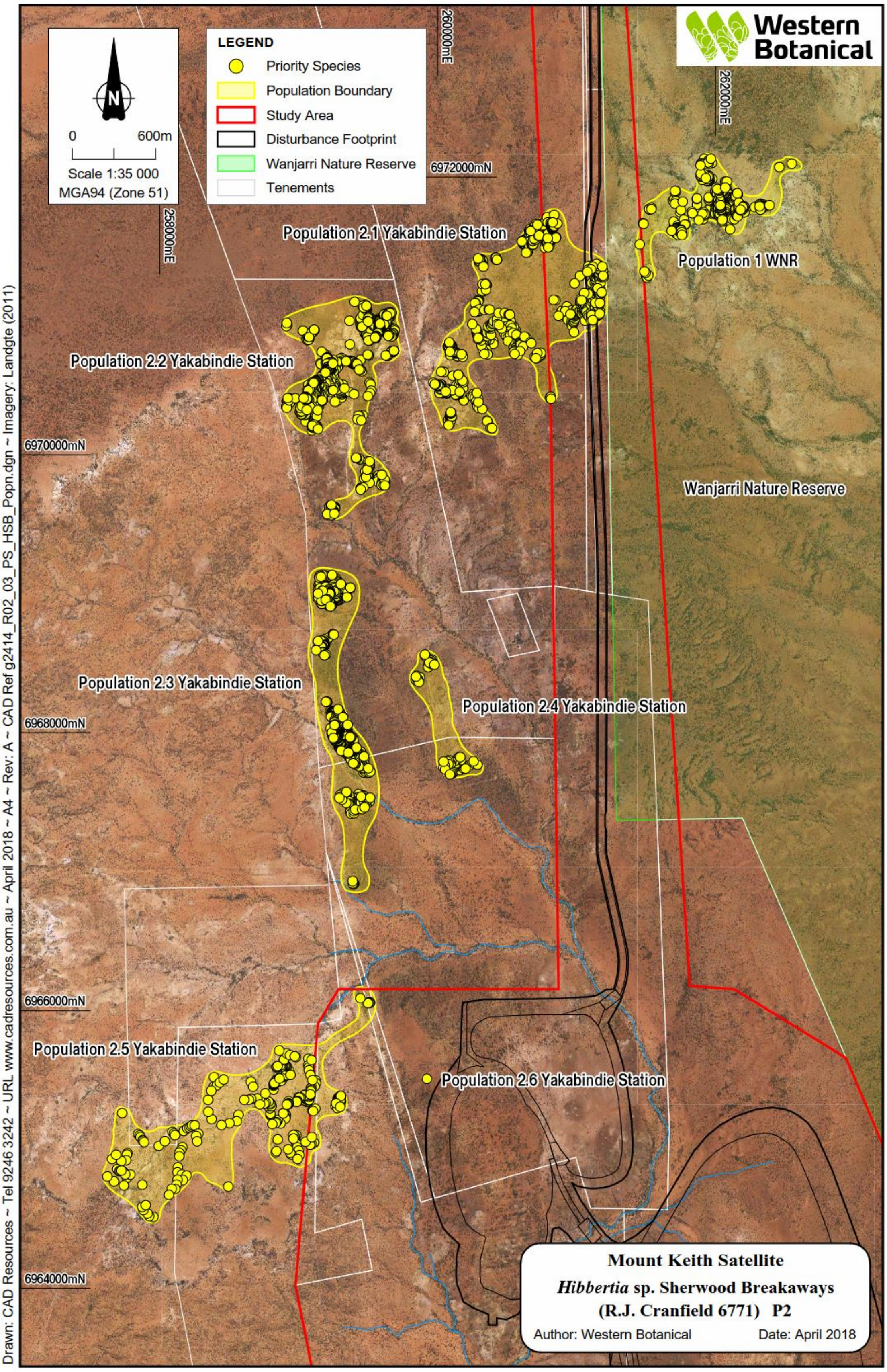
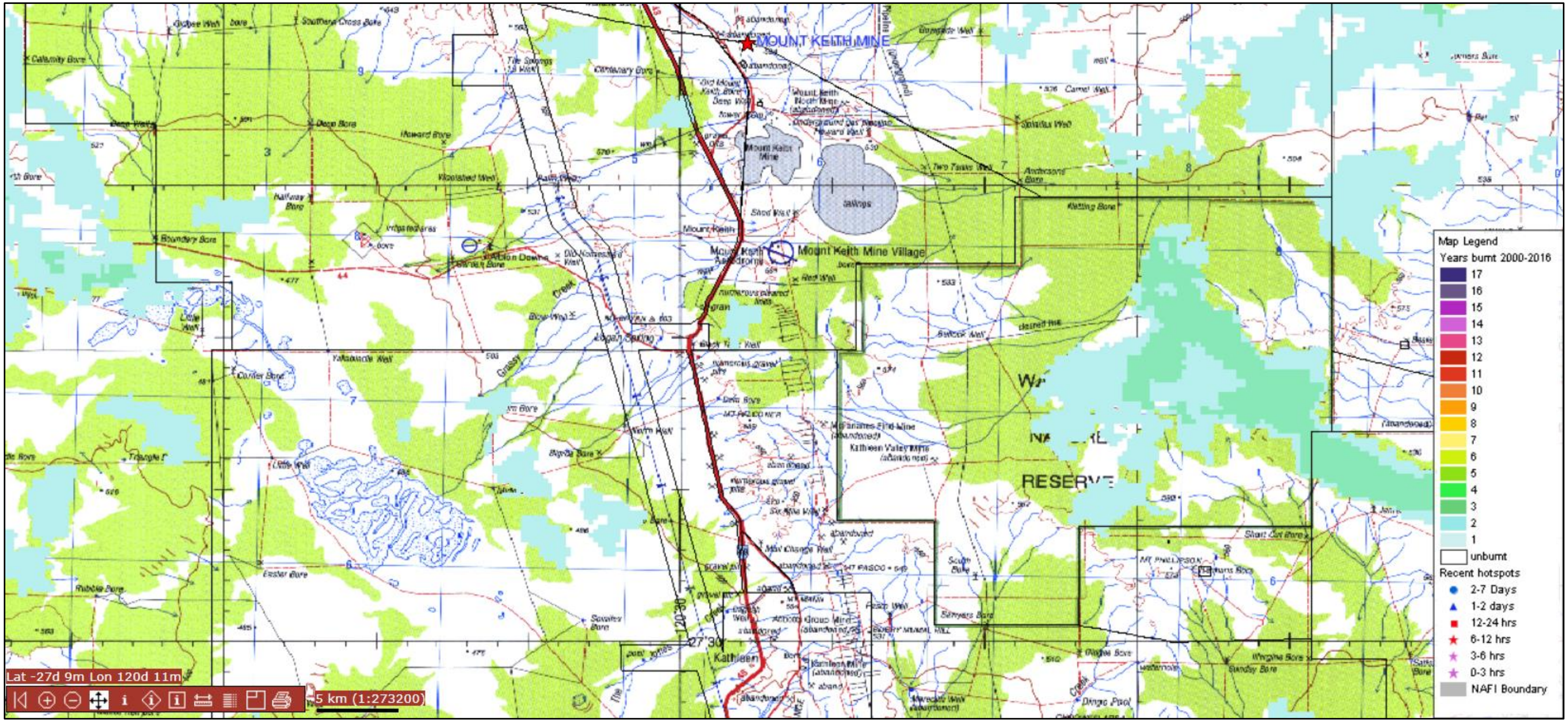


Figure 22 *Hibbertia* sp. Sherwood Breakaways populations



Source: North Australia Fire Information Database, November 2017

Figure 23 Fire History for Proposal Area

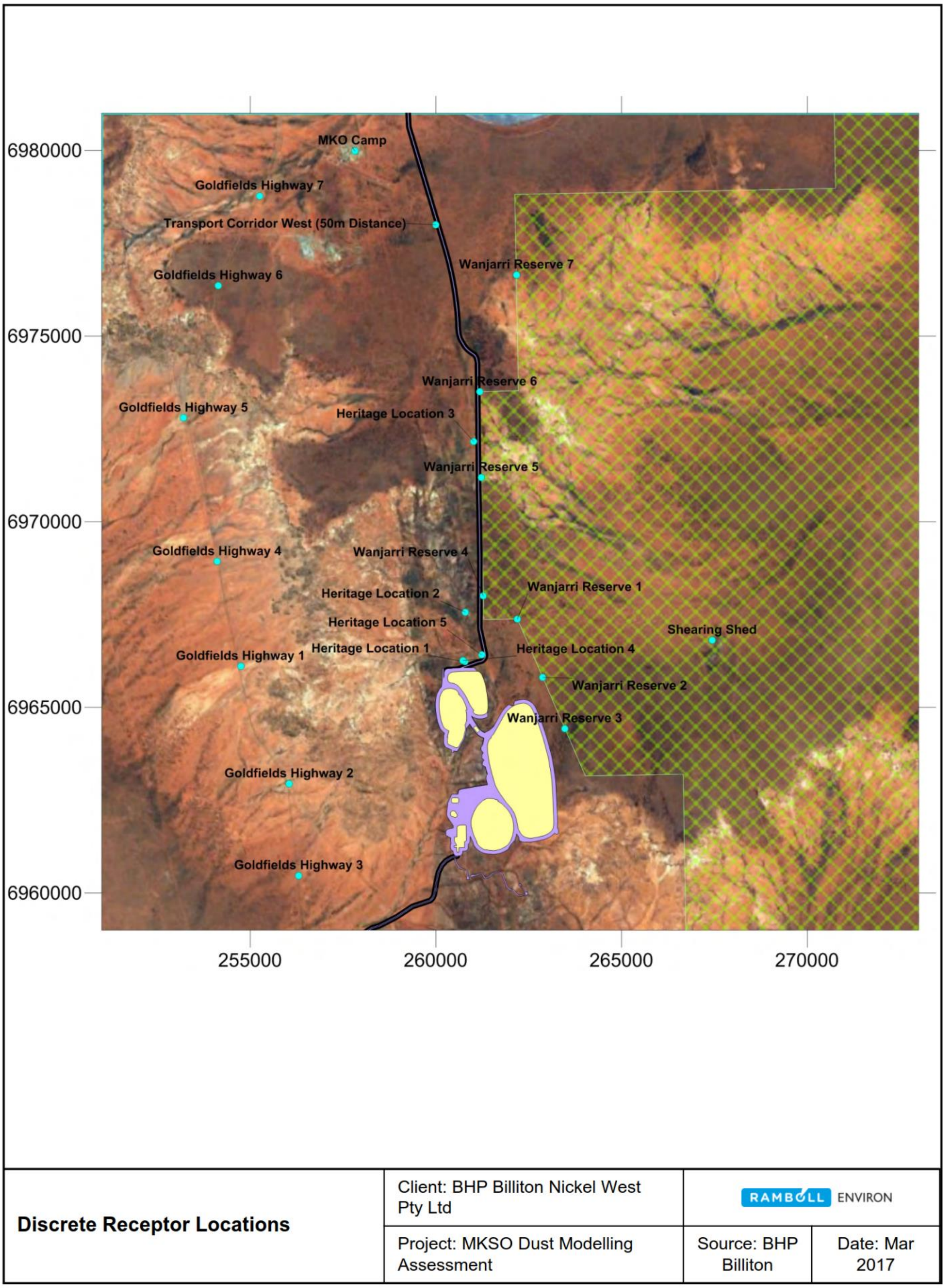


Figure 24 Mt Keith Satellite Dust Receptor Locations

A summary of the predicted average daily deposition rates for a range of scenarios is presented in Table 22.

Table 22 Summary of predicted daily average dust deposition at sensitive receptor locations

Location	Predicted daily deposition (g/m2/d)*		
	Scenario 1 No dust controls NMK Transport Road	Scenario 2 Watering <2 l/m^2/hr NMK Transport Road	Scenario 3 Watering > 2 l/m^2/hr NMK Transport Road
Wanjarri Nature Reserve 1	0.020	0.012	0.008
Wanjarri Nature Reserve 2	0.029	0.026	0.024
Wanjarri Nature Reserve 3	0.035	0.034	0.033
Wanjarri Nature Reserve 4	0.252	0.128	0.066
Wanjarri Nature Reserve 5	0.198	0.099	0.050
Wanjarri Nature Reserve 6	0.239	0.120	0.060
Wanjarri Nature Reserve 7	0.009	0.005	0.003
Transport Corridor West	0.288	0.144	0.072

* The modelled dust values nearing or exceeding the Doley and Rossato (2010) trigger level of 0.3 g/m2/day are highlighted orange.

The modelling predicted the greatest impacts at the selected receptor locations within the Wanjarri Nature Reserve to occur at Wanjarri Nature Reserve 4 (WR4). However, the greatest impacts occur to the west of the transport corridor. Impacts at the Transport Corridor West receptor, which is located within 50m of the centre of the transport corridor were predicted to be greater than in the reserve. Analysis of the wind directions indicates that the winds are predominately from an easterly or south-easterly direction and so the greatest depositional impacts are expected to occur on the western side of the road corridor outside of the Wanjarri Nature Reserve.

Based on a depositional trigger value of 0.3 g/m2/day, the predicted impacts to vegetation within the Wanjarri Nature Reserve from activity along the transport corridor with no controls applied is likely to be low. However, water based dust suppression will be utilised during both construction and operational phases of the Proposal to minimise dust impacts on adjacent vegetation on either side of the transport corridor. It is unlikely that any health impacts to vegetation will result from dust.

5.5 Mitigation, residual impacts and outcomes

A summary of the key mitigation measures to address potential impacts on flora and vegetation are listed in Table 23. This includes consideration of mitigation strategies required to manage inherent impacts and residual impacts after the application of these measures. These strategies are addressed in a Flora and Vegetation Management Plan (Appendix C) which ensures residual impact are not greater than predicted and includes:

- invasive species control of weeds;
- monitoring program for significant flora and vegetation communities; and
- adaptive management actions.

Monitoring and management actions associated with Closure are addressed in the Mine Closure Plan (Appendix E). The Significant Residual Impact Model as detailed in the WA Environmental Offsets Guidelines (2014) has been applied to the Proposal, as detailed in Table 67.

Table 23 Environmental Management of Flora and Vegetation

EPA Objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained	
Inherent Impacts Requiring Management	**Mitigation Strategies**	**Outcomes**
Clearing of native vegetation resulting in loss and/or fragmentation of vegetation communities, particularly those of the Violet Range PEC, Wanjarri Nature Reserve and Priority species; and altered fire regime and associated change and/or loss of vegetation. Dust from mining activities resulting in reduced health and condition or loss of significant flora, including vegetation within Wanjarri Nature Reserve. Mining activities resulting in increased spread of weeds and potential for cumulative impacts such as altered fire regimes	**Avoid** • Disturbance footprint designed to reduce disturbance to Priority flora. • Vegetation clearing to be limited to Proposal Disturbance Footprint, with no clearing or mining activities to occur within Wanjarri Nature Reserve. • Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to individuals of the P2 flora Hibbertia sp. Sherwood Breakaways • Waste Rock Landform design will avoid direct impact to individual *Hibiscus krichauffianus* (P3) **Minimise** • Land disturbance kept to minimum necessary for development of the Proposal within the design footprint. • Existing internal ground disturbance procedures and permitting system will be implemented. • Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. • Dust suppression, including use of water carts on access roads, to be used during construction, operation and closure activities. • Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to the Proposal via transport route. • Implement biannual weed monitoring and targeted spraying program following completion of land clearing activities and during operations and closure activities. • Firefighting equipment will be located on site and emergency personnel will be trained in fire response • A Hot Work Permit system will be implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Proposal site induction to include information on prevention and management of fires. • Clearing, topsoil stripping and stockpiling will be undertaken in accordance with NiW procedures. • Undertake monitoring and adaptive management in accordance with the Flora and Vegetation Environmental Management Plan (Appendix C) **Rehabilitate** • Targeted seed collection for the species Hybanthus floribundus subsp. chloroxanthus for use in rehabilitation. • Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	**Residual Impact and Outcomes** The following residual impacts are considered to be of minor significance at both local and regional scale. ○ Clearing will necessitate the removal of a number of Priority plants from the Disturbance Footprint. Monitoring will be undertaken to assess any indirect impacts to the PEC and certain Priority species. Minor disturbance to Jones Creek will occur in the formation of two creek crossings. ○ Clearing will directly impact 3.76% of the Violet Range PEC (Disturbance Footprint) with possible indirect impacts up to 5.24% (Development Envelope). ○ Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale so long as targeted weed management programs are maintained. No impacts on flora and vegetation of the Wanjarri Nature Reserve will occur. NiW considers that clearing required for the Proposal will not have significant residual impacts and meets the objective for this factor. **Offsets** Based on the expectation that the clearing will not have significant residual impacts, no offsets are proposed.

6 Terrestrial Fauna

6.1 EPA objective, policies and guidelines

The EPA's objective for terrestrial fauna is:

> "to protect terrestrial fauna so that biological diversity and ecological integrity are maintained;"

where "ecological integrity" is the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements.

The EPA defines terrestrial fauna for the purposes of EIA, as:

> "animals living on land or using land (including aquatic systems) for all or part of their lives. Terrestrial fauna includes vertebrate (birds, mammals including bats, reptiles, amphibians, and freshwater fish) and invertebrate (arachnids, crustaceans, insects, molluscs and worms) groups."

The EPA defines fauna habitat as *"the natural environment of an animal or assemblage of animals, including biotic and abiotic elements, that provides a suitable place for them to live (e.g. breed, forage, roost or seek refuge)".*

The policy and guidance documents considered in the environmental impact assessment for this factor are listed in Table 24. The ERD is consistent with these documents.

Table 24 Policy and guidance relevant to Terrestrial Fauna

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016).	Outlines how the EPA considers terrestrial fauna in the EIA process, including how this factor links with other environmental factors.	The ERD describes the vertebrate and SRE invertebrate faunal habitat and likely occurrence of Priority species, within the Study Area. The area has been subject to intensive, systematic vertebrate fauna survey to date, exceeding EPA requirements, and several SRE invertebrate fauna surveys. The ERD demonstrates that clearing impacts will be of minor significance at local and regional scale and can be adequately managed through the implementation of appropriate mitigation measures. Furthermore, the remaining available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of Priority vertebrate and SRE invertebrate species.
Other Policy and Guidelines		
Survey Guidelines for Australia's Threatened Mammals (Department of Sustainability, Environment, Water, Population and Communities, 2011).	Provides guidelines for surveying Australia's threatened non-flying mammals listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). These survey guidelines provide guidance on what should be considered when planning and undertaking species presence surveys for threatened mammals relevant to a referral to the Federal Environment Minister under the EPBC Act.	The Proposal was referred to the EPBC in August 2017, in relation to the proposed action (clearing of native vegetation) likely to impact on members of any listed threatened species, threatened environmental communities or their habitat (i.e. Night Parrot, Mallee fowl, Black-footed Rock –wallaby).Targeted surveys for these species were undertaken in 2017, for which the survey methodology is consistent with this guidance.
Technical Guidance – Sampling of Short Range Endemic Invertebrate Fauna (EPA, 2016).	Provides guidance on the general standards and a common framework including risk-based assessment for the sampling and assessment of short range endemic (SRE) invertebrate fauna for EIA	Fauna surveys undertaken for this Proposal were conducted in accordance with EPA guidance current at the time.

Policy and Guidelines	Key Aspects	Application
	in Western Australia. It also sets out the EPA's current expectations in respect of the quality and quantity of information derived from these surveys, and the consequent analysis, interpretation and reporting. This document currently retains the format and content of EPA Guidance Statement No 20, "Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia" (EPA 2004).	The SRE survey report for the Proposal (Appendix H) refers to surveys completed in 2011 and 2012, which were designed and conducted in accordance with EPA policy applicable at the time: WA Environmental Protection Authority (EPA) Guidance No. 20, Sampling of Short -range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009); EPA Guidance No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004); and EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).
Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (EPA, 2016).	Provides direction and information on general standards and protocols for terrestrial fauna surveys to environmental consultants and proponents engaged in EIA activities. This document currently retains the format and content of EPA Guidance Statement No 56, "Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia" (EPA 2004).	The Fauna survey undertaken for the Proposal (Appendix I) reviewed work relevant to the Study Area, undertaken in 2005 and 2006.These surveys were conducted in accordance with EPA policy applicable at the time: EPA Position Statement No. 3, "Terrestrial Biological Surveys as an Element of Biodiversity Protection" (EPA 2002); EPA Guidance Statement No 56, "Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia" (EPA 2004) Targeted fauna surveys were undertaken for Night Parrot and Black-footed Rock-wallaby in June 2017 and July 2017 respectively (Appendices J and K).
WA Environmental Offsets Policy (The Government of Western Australia, 2011).	This policy provides a framework for the consistent application of environmental offsets to protect and conserve environmental and biodiversity values.	These documents have guided the consideration of whether or not offsets are required for the Proposal, where the offset is an offsite action(s) to address significant residual environmental impacts of the development. The impact assessment undertaken for this Proposal has considered that there are no significant residual impacts requiring the development of offsets
WA Environmental Offsets Guidelines (The Government of Western Australia, 2014).	These guidelines complement the WA Environmental Offsets Policy (Government of Western Australia, 2011) by clarifying the determination and application of environmental offsets in Western Australia. These guidelines expand on the offsets policy to ensure that the basis for decision-making on environmental offsets is understood by decision-makers.	

6.2 Receiving environment

Vertebrate Fauna Study Area and survey effort

The Study Area (Figure 25) and surrounds has been subject to systematic fauna surveys, as listed in Table 25.

Table 25 Fauna Surveys

Author	Title	Level of Survey	Targeted Groups	Date	Comment
Biota Environmental Sciences. Prepared for BHP Billiton	Mt Keith Satellite Proposal Vertebrate Fauna Review.	Desktop Review	Vertebrate and SRE	October 2017	Integration report compiled to inform this assessment
Biota Environmental Sciences. Unpublished report for BHP Billiton	Mt Keith Satellite Proposal Night Parrot Survey.	Targeted	Night Parrot	October 2017	Targeted surveys undertaken in 2017 to address specific knowledge gaps relating to Priority species. Results summarised in Biota, 2017c (Appendices K and L).
Biota Environmental Sciences. Unpublished report for BHP Billiton	Mt Keith Satellite Proposal Black-footed Rock-wallaby Survey.	Targeted	Black-footed Rock-wallaby	October 2017	
ATA Environmental. Unpublished report for SKM Consulting/BHP Billiton.	Fauna Assessment, Western Mining Corporation, Yakabindie.	Level 2	Vertebrate and SRE	2005	The records of these surveys were reviewed as directly relevant to the Study Area as they included sites within the Study Area or within a mapped habitat unit that is continuous with, or within 10 km of the Study Area.
Biota Environmental Sciences. Unpublished report for SKM Consultants/BHP Billiton.	Wanjarri Land Swap Proposal: Ecological Assessment.	Level 2	Vertebrate and SRE	2006	
Biota Environmental Sciences. Unpublished report for BHP Billiton Nickel West.	Fauna Habitat and Fauna Assemblage of the Mt Keith Mine Proposal Area.	Level 2	Vertebrate	2006	
Ecologia Environmental Consultants. Unpublished report for Dominion Mining Limited.	Yakabindie Nickel Mine Proposal. Consultative Environmental Review: Flora and Fauna Survey.	Level 2	Vertebrate	1990	The close proximity of the Study Area to the Mt Keith Operations and the Wanjarri Nature Reserve places it in context of numerous other fauna surveys having been conducted in the local area (Figure 25) including these and Moriarty, 1972
Ecologia Environmental Consultants. Unpublished report for Dominion Mining Limited.	An ecological assessment of the Yakabindie Nickel Mine Proposal: Six Mile Well / Mount Pascoe.	Level 2	Vertebrate	1995	
Hall et. al (1994) Records of the Western Australian Museum. Supplement 47.	Part 10, (Sandstone–Sir Samuel and Laverton–Leonora Study Areas) of the biological survey of the Eastern Goldfields of Western Australia.	Level 2 style survey	Vertebrate	1994	
Moriarty. The Emu. Vol 72 (part 1)	Birds of Wanjarri.	N/A	Birds	1972	This study recorded birds at the Wanjarri Nature Reserve across three decades and produced one of the most complete avifauna assemblages for an arid zone location.
Biota Environmental Sciences. Unpublished report for SKM Consultants/BHP Billiton.	Fauna and Habitats of the Lake Way and South Lake Way Borefields.	Level 2	Vertebrate and SRE	2006	These surveys in the wider area were also reviewed by Biota for records of Priority fauna species and descriptions of habitat from which they were recorded. This information was then used in the assessment of the likelihood of these species occurring within the Study Area.
Biota Environmental Sciences. Unpublished report for SKM Consultants/BHP Billiton.	Survey of fauna habitats and the fauna assemblages of the Albion Downs Borefied Pipeline area.	Level 2	Vertebrate and SRE	2010	
Bamford Consulting Ecologists. Report prepared for URS Australia.	Vertebrate fauna assessments of the Yeelirrie Proposal.	Level 2	Vertebrate	2011, 2015	

In addition to the surveys listed in Table 25, early records of the Mulgara (then Schedule 1) from the Wanjarri Nature Reserve (Ecologia 1990) resulted in numerous Mulgara surveys being undertaken in the locality, particularly on Mt Keith, Albion Downs and Barwidgee Stations (Halpern Glick Maunsell 1997a, 1997b, 1999, 2000; Biota 2004, 2006d; and ATA 2005b) (Biota, 2017c).

Relative to the size of the Study Area, the level of past systematic survey has been intensive with all but one of the broad fauna habitats present (Hills and Slopes with Chenopod shrublands) having been sampled by multiple trapping sites. The intensity, type and cross-seasonality of the overall fauna sampling effort previously expended exceeds the current recommended EPA requirements. The likely fauna assemblage of the Study Area can therefore be confidently described both from surveys within the Study Area and also the fauna surveying conducted as part of the environmental impact assessment of the nearby Mt Keith Operations and historical sampling within the adjacent Wanjarri Nature Reserve (Biota, 2017c).

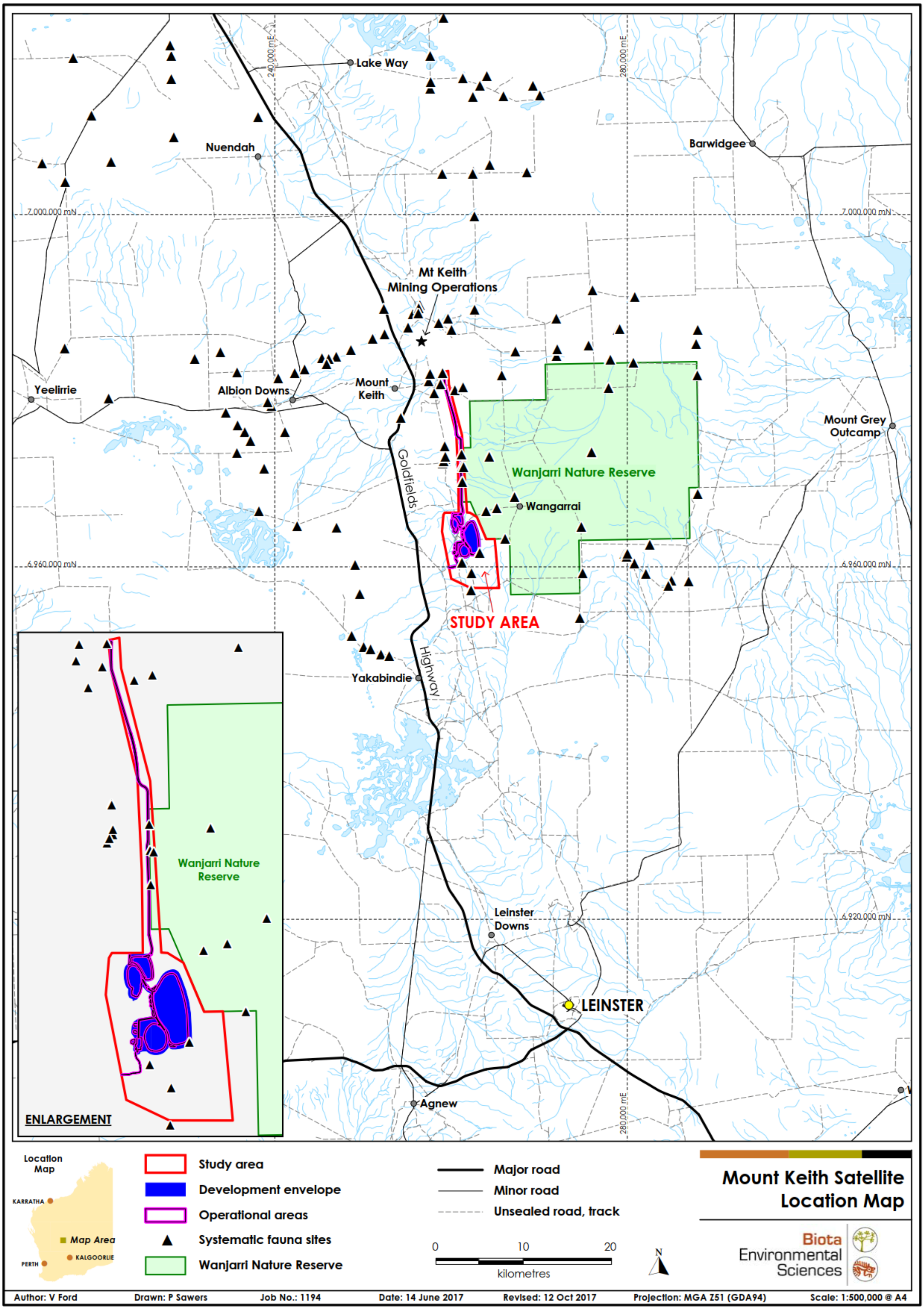


Figure 25 Fauna Study Area and Development Envelope, with local and regional previous fauna survey sites

Table 26 details the three systematic inventory fauna surveys that either have sites within the Study Area or within the same mapped habitat units of the Study Area. Seven vertebrate fauna trapping sites have been located within the Study Area during past surveys; three using a combination of pit, funnel, Elliott and cage traps, two using pit traps only, one using Elliott traps only and one using a harp trap for bats. In addition to the sites located within the Study Area, 21 previous systematic fauna sites fell within the same mapped habitat units present within the Study Area, and in most cases where they were continuous with the Study Area, or otherwise where the same habitat unit had been mapped within 10 km. The location of these relative to the Study Area and Development Envelope is given in Table 24 and shown in Figure 26.

For the purposes of impact assessment, all 28 systematic vertebrate fauna sampling sites were considered in order to represent the effort that has been historically applied to the Study Area. Sampling effort at these 28 sites is detailed in Table 26. Targeted surveys for the Night Parrot (*Wildlife Conservation Act 1950* (WC Act), Schedule 1 and EPBC Act, Endangered) and Black-footed Rock-wallaby (WC Act Schedule 2, EPBC Act Endangered) have been conducted over the Study Area and immediate surrounds during 2017.

Table 26 Systematic vertebrate survey effort applied to the Study Area

Project	Survey Type	Location relative to Study Area	Site IDs	Pit Trap Nights	Funnel Trap Nights	Elliott Trap Nights	Cage Trap Nights	Harp Nights
Yakabindie Fauna Assessment (ATA 2005)	Single-phase Level 2 (3/11/2004 - 13/11/2004)	Sites within Study Area	ATA8, ATA9, ATA10	260	550	130	70	
		Within mapped habitat unit	ATA7, ATA11, ATA12, ATA13, ATA14, ATA15, ATA16	690	1380	345	207	
Wanjarri Land Swap Proposal (Biota 2006a)	Two-phase Level 2 (25/11/2005 - 05/12/2005, 06/03/2006 - 13/03/2006)	Sites within Study Area	YAK12, YA13, YAK15E, YAKHARP5	288		300		6
		Within mapped habitat unit	YAK08	144				
Fauna habitats and fauna assemblage survey of the Mt Keith Mine Project area	Single-phase Level 2 (16/03/2006 - 23/03/2006)	Sites within Study Area	-	-	-	-	-	-
		Within mapped habitat unit	MKM01E, MKM02, MKM03, MKM04, MKM05, MKM06E, MKM07, MKM09A, MKM10, MKM11, MKMHARP1	792		100		15
		Summary of Effort within Study Area		548	550	430	70	6
		Summary of Effort within mapped habitat unit		1626	1380	445	207	15
		TOTAL		**2174**	**1930**	**875**	**277**	**21**

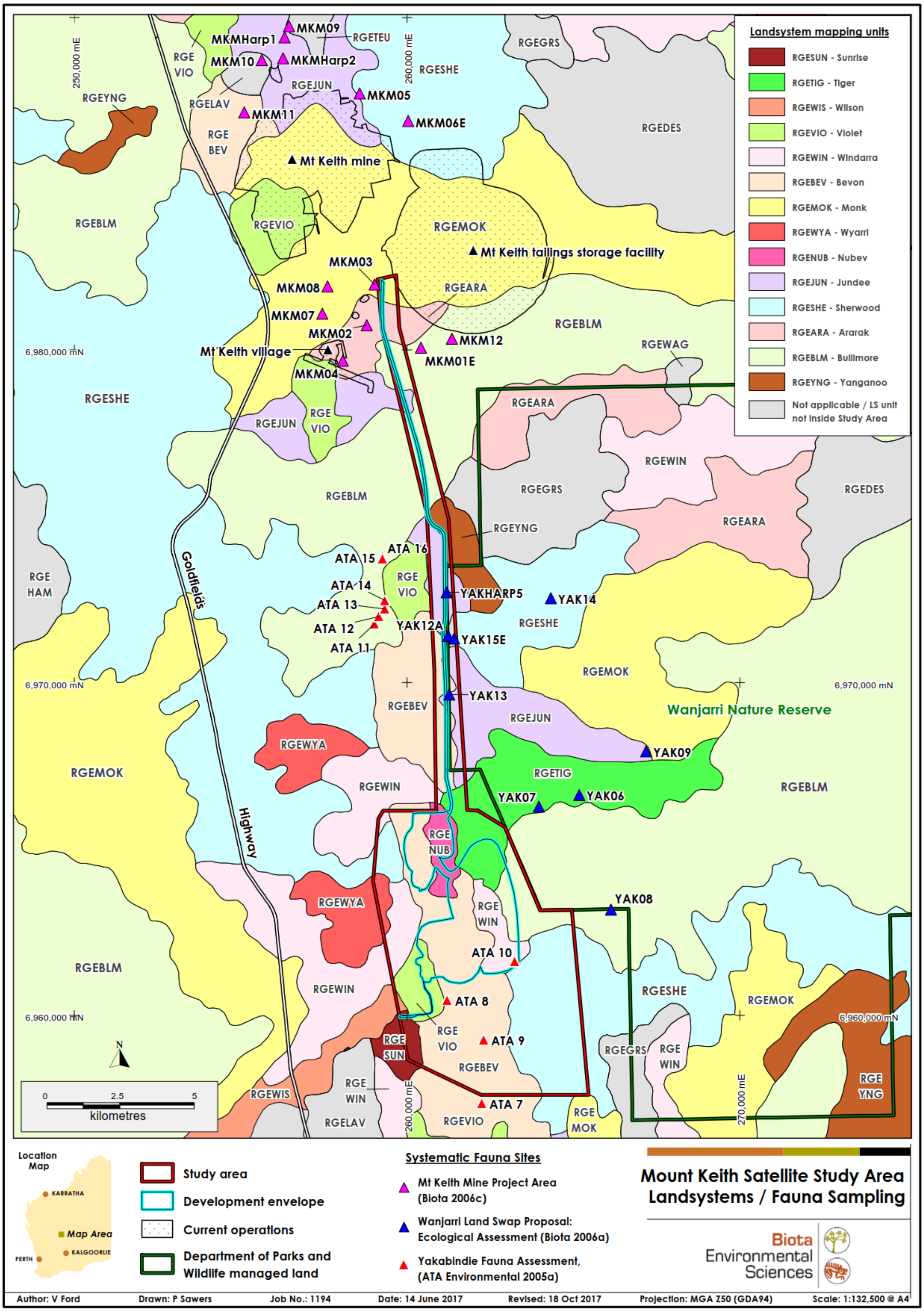


Figure 26 Survey sites reviewed as directly relevant to the Study Area

Terrestrial Vertebrate Habitat

Eight terrestrial vertebrate fauna habitats were described for the Study Area based on vegetation mapping (Western Botanical 2017), geology, landform and soils:

- Hills and Slopes, Sclerophyll Shrublands
- Undulating Plains, Sclerophyll Shrublands
- Drainage tract – Mulga
- Undulating Plains Grass Dominated
- Undulating Plains – Chenopod Shrublands
- Areas of Internal Drainage – Mulga
- Drainage Line
- Hills and Slopes, Chenopod Shrublands

None of the fauna habitats within the Study Area are restricted to this area, based on the broader distribution of vegetation communities and land system types, as shown in Figures 23 to 28 (Biota, 2017c).

Fauna Assemblage

The 28 fauna survey sites within the Study Area have yielded 135 vertebrate species, comprising 17 mammals, 77 birds and three frogs. A full list of all species recorded is provided in Biota, 2017c (Appendix I).

Mammals

The 17 mammal species recorded in total represents 68% of potential mammal assemblage returned from the NatureMap database. At a bioregional level, the area is not known to support any endemic mammal taxa.

Two Priority mammal species have been recorded either from within the Study Area or the local area:

- Brush-tailed Mulgara (*Dasycercus blythi* DBCA Priority 4); and
- Long-tailed Dunnart (*Sminthopsis longicaudata*, DBCA Priority 4).

Black-footed Rock-wallaby (*Petrogale lateralis*, WC Act: Schedule 2, EPBC Act: Endangered) is known from a 2006 sighting 13.5 km west of the northern end of the transport corridor.

The majority of extant non-volant species known for the bioregion have been recorded from the broader area surrounding the Study Area, and this includes the Priority 4 species *Dasycercus blythi* and *Sminthopsis longicaudata*.

The bat assemblage of the local area, which includes 6 species, is still well represented and known to support one Priority listed species, *Nyctophilus major tor* (P4), which was not recorded within the Study Area but from the wider area (Yeelirrie 50 km west of the Study Area). The Priority 4 ranking of this species means that it is not regarded as threatened or endangered and no additional studies are therefore warranted. Woinarski et al. (2014) identify the conservation ranking for this species as Least Concern (Biota, 2017c).

Birds

Previous surveys of the Study Area have recorded a combined total of 77 species of birds, which represents 70% of 110 potential species indicated in the NatureMap records from within 20km of the Study Area. Given that the Wanjarri Nature Reserve represents the most intensely surveyed arid zone site for which published data is available, it is expected that most species likely to occur in the region have been recorded.

Two WC Act Schedule and two DBCA Priority 4 listed bird species have been recorded in the vicinity of the Study Area, or may occur there based on their known distribution:

- Malleefowl (*Leipoa ocellata*, WC Act Schedule 3, EPBC Act Vulnerable);
- Peregrine Falcon (*Falco peregrinus*, WC Act Schedule 7);
- Princess Parrot (*Polytelis alexandrae*, Priority 4); and
- Striated Grasswren (*Amytornis striatus*, Priority 4).

There have been recent confirmed sightings of the Night Parrot (*Pezoporus occidentalis* Schedule 1) in the Murchison Bioregion.

One WC Act Schedule 5 (migratory) listed species has been recorded in the vicinity of the Study Area:

- Rainbow Bee-eater (*Merops ornatus*, WC Act Schedule 5).

In addition, a number of migratory bird species were returned from the EPBC Act Protected Matters database search as species that may occur in the Study Area based on known distributions or habitat preferences:

- Grey Wagtail (*Motacilla cinerea*, WC Act Schedule 5; EPBC Act Migratory);
- Yellow Wagtail (*Motacilla flava*, WC Act Schedule 5; EPBC Act Migratory);
- Common Sandpiper (*Actitis hypoleucos*, WC Act Schedule 5; EPBC Act Migratory);
- Sharp-tailed Sandpiper (*Calidris acuminata*, WC Act Schedule 5; EPBC Act Migratory);
- Pectoral Sandpiper (*Calidris melanotos*, WC Act Schedule 5; EPBC Act Migratory);
- Oriental Plover (*Charadrius veredus*, WC Act Schedule 5; EPBC Act Migratory).

These migratory species may visit ephemeral or semi-permanent pools of water in Jones Creek and/or nearby salt lakes following episodic rain events. Drainage line habitats within the Study Area, such as Jones Creek, may be of periodic local significance to these species as refugia and foraging habitats. However, despite potential for occasional use of watered habitats within the Study Area, these species are unlikely to be dependent on these habitats in a regional context, as they have a broader distribution across Western Australia (Biota, 2017a). In addition, the Proposal seeks to mitigate impacts to Jones Creek and maintain its hydrological function (Table ES2), in order to protect terrestrial fauna species such as these migratory bird species.

Reptiles

The 38 species of reptiles recorded in the Study Area represents 63% of historical records within 20km of the Study Area returned form NatureMap (61 species). The only vertebrate species considered endemic to the Murchison bioregion is the Spotted Mulga Snake (*Pseudechis butleri*) (Storr et al. 2002). This species was observed at Albion Downs, by a BHP Billiton employee (Mr Craig Pollock, pers. comm. 2008). This species has not been recorded from the Study Area, Mt Keith or Wanjarri Nature Reserve (Biota, 2017a).

No reptile species of conservation significance have been recorded from the surveys of Mt Keith and the surrounds (ATA 2005a; Biota 2006a, 2006b, 2006c, unpublished data). The trapping effort across these surveyed areas tallies over 14,000 trap nights (including pits, funnels and Elliotts). There is one historical record of the Great Desert Skink (*Liopholis kintorei*) from Kathleen Station (approximately 8 km north of the Study Area) (Biota, 2017c).

Amphibians

Three species of frogs have been recorded from the Study Area while eight were returned from a NatureMap database search as potentially occurring. The recording of frogs in arid areas is generally reliant on significant episodic rainfall events that rarely occur during systematic fauna surveys, which are typically timed for the drier times of year preferable for sampling the majority of fauna species. While it can be difficult to ascertain the full amphibian assemblage of a Study Area due to their cryptic nature during dry conditions, Biota do not consider there to be any major knowledge gaps in the assemblage, taking into account the relatively intensive survey effort across the broader region around Mt Keith, including the Study Area (Biota, 2017c).

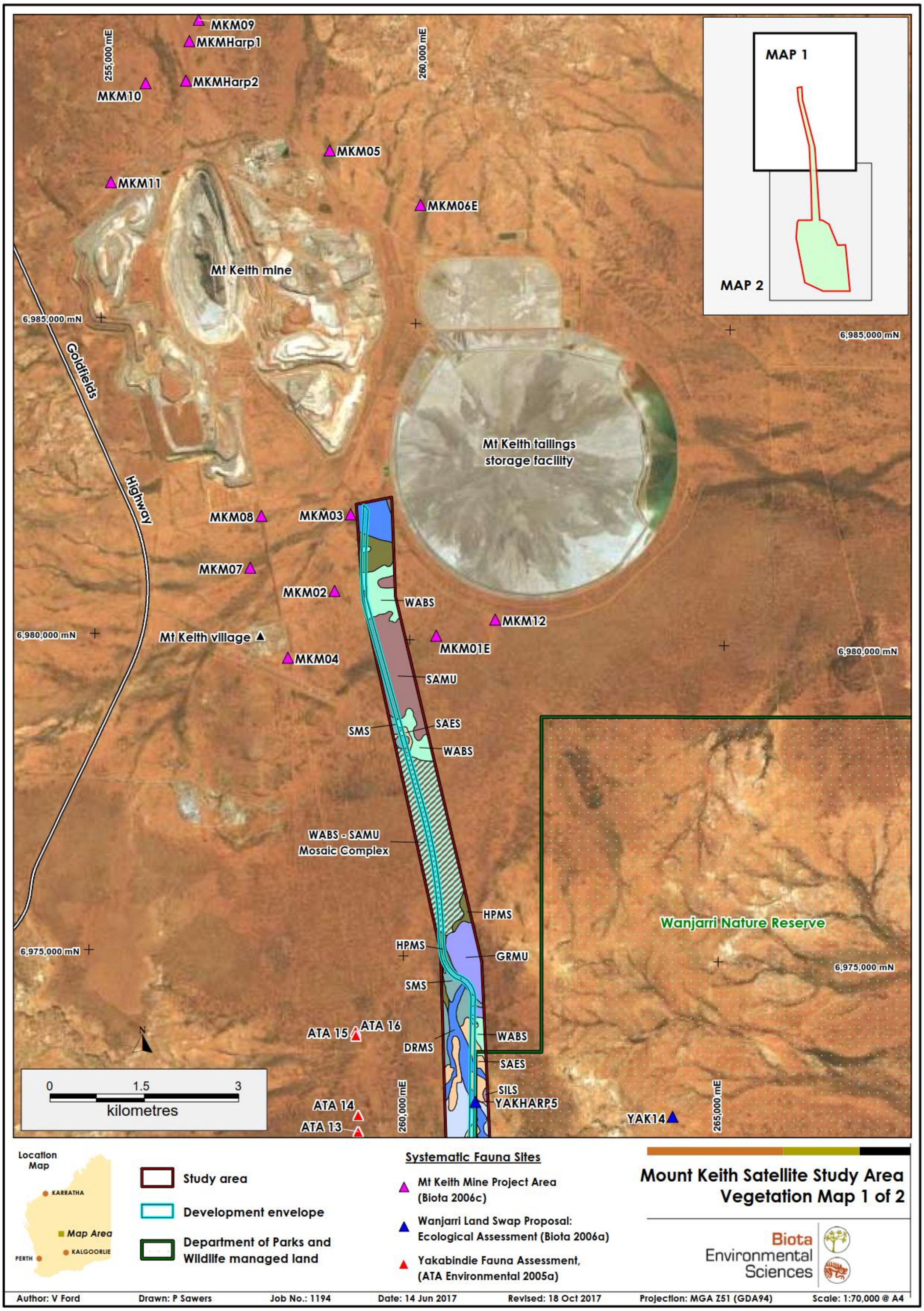


Figure 27 Study Area Vegetation Map and Fauna Survey Sites Map 1 of 2

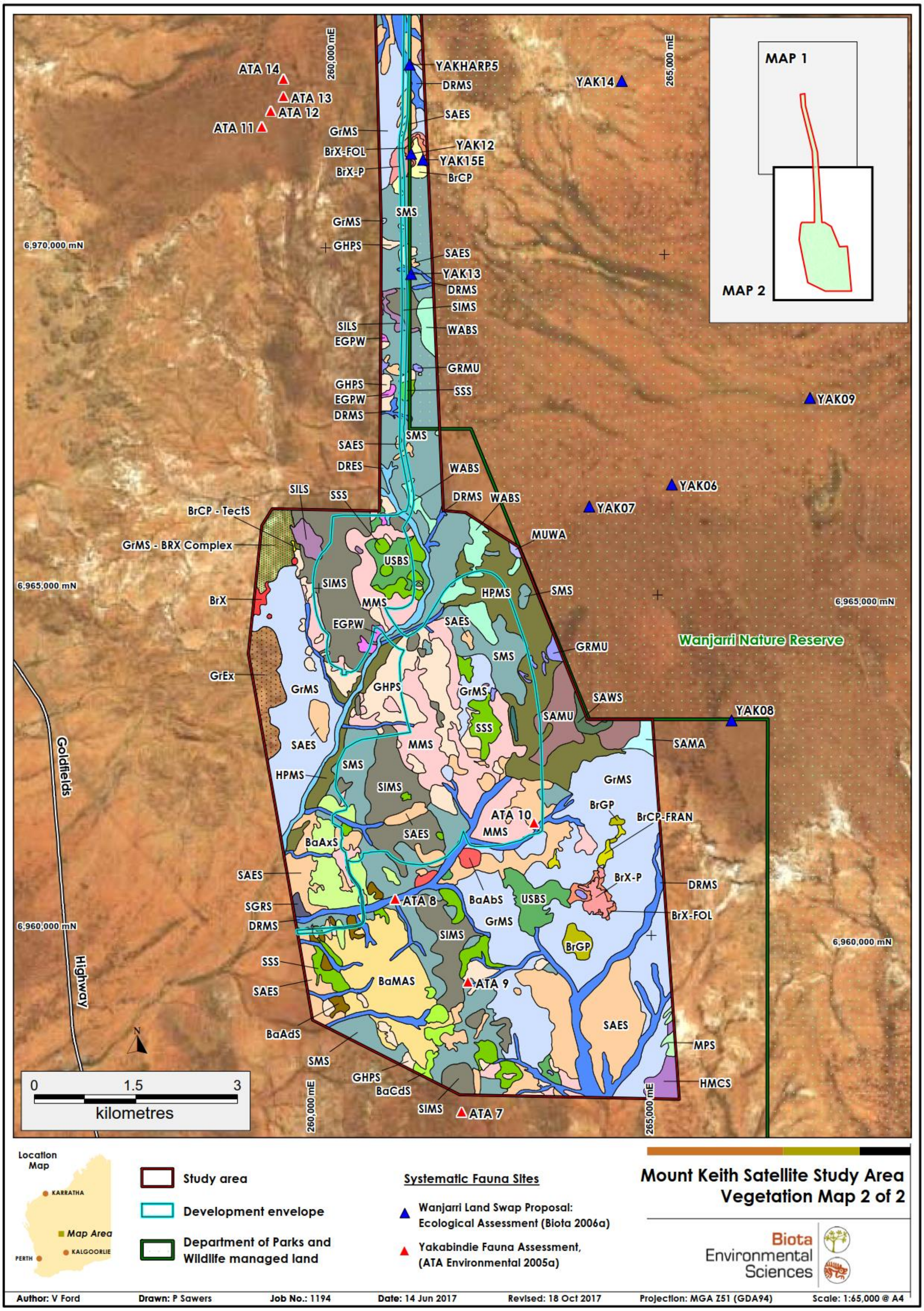


Figure 28 Study Area Vegetation Map and Fauna Survey Sites Map 2 of 2

Vegetation of Mount Keith Satellite Study Area

BaAbS	Basalt, *Acacia burkittii* Shrubland (component of the BaMAS complex)	HMCS	Mulga Shrubland with scattered low Chenopod Shrubs
BaAdS	Basalt, *Acacia* aff. *doreta* Shrubland (component of the BaMAS complex)	HPMS	Hardpan Mulga Shrubland
BaAxS	Basalt, *Acacia* aff. *xanthocarpa* Shrubland (component of the BaMAS complex)	HPMS THOMA	Hardpan Mulga (*Acacia thoma*) Shrubland
BaCdS	Basalt, *Calytrix desolata* low Shrubland	MMS	Mulga over *Maireana triptera* Shrubland
BaMAS	Basalt, mixed *Acacia* species Shrubland Complex	MPS	*Maireana pyramidata* Shrubland
BrCP	Breakaway Chenopod Plain Complex	MUWA	Mulga - Wanderrie Grassland
BrCP - TectS	Breakaway Chenopod Plain Complex - *Tecticornia* Shrubland (component of the BrCP Complex)	SAES	Stony *Acacia* - *Eremophila* Shrubland
BrCP-FRAN	Breakaway Chenopod Plain Complex - *Frankenia* shrubland (component of the BrCP Complex)	SAMA	Sandplain, Mallee, *Acacia* species Spinifex Shrubland
BrGP	Breakaway Grassy Plain	SAMU	Sandplain Mulga Spinifex Shrubland
BrX	Archaean Granite Breakaway	SAWS	Sandplain, *Acacia* species Spinifex Shrubland
BrX-FOL	Archaean Granite Breakaway Footslope	SGRS	Sandy Granitic Mulga Shrublands
BrX-P	Archaean granite geology	SILS	Stony Ironstone Low Shrubland
DRES	Drainage Line Eucalypt Woodland	SIMS	Stony Ironstone Mulga Shrubland
DRMS	Drainage Line Mulga Shrubland	SMS	Stony Mulga Shrubland
EGPW	Weathered Basalt, *Eucalyptus gypsophila* - *Eremophila pantonii* Woodland	SSS	Stony *Senna* Shrubland
GHPS	Weathered Basalt, *Hakea leucoptera* subsp. *sericipes* - *Eremophila pantonii* Shrubland	USBS	Upland Small Bluebush Shrubland
GrEx	Granite, Exfoliating granite outcrops	WABS	Wanderrie Bank Grassy Shrublands
GrMS	Granitic Mulga Shrubland	WABS-SAMU Mosaic Complex	Wanderrie Bank Grassy Shrublands/ Sandplain Mulga Spinifex Shrubland
GrMS - BRX Complex	Granite Mulga Shrubland - Granite Breakaway Plateaux Complex		Ponded Water
GRMU	Groved Mulga Woodland		Disturbed

Vegetation Type Descriptions for the Mount Keith Satellite Vegetation Maps

Legend Sheet 1

Biota Environmental Sciences

Figure 29 Vegetation type descriptions for Vegetation maps

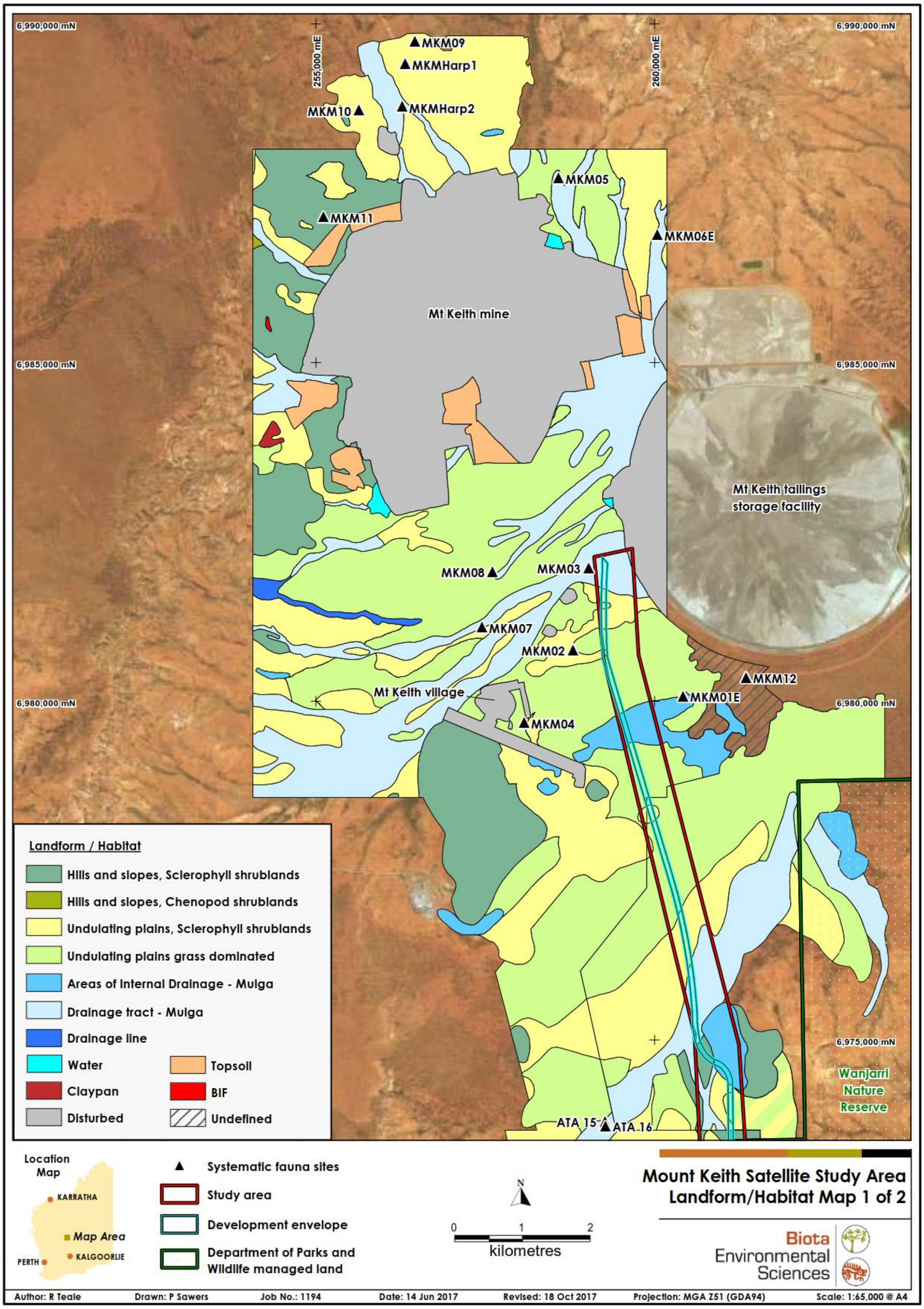


Figure 30 Landform/Habitat Map 1 of 2

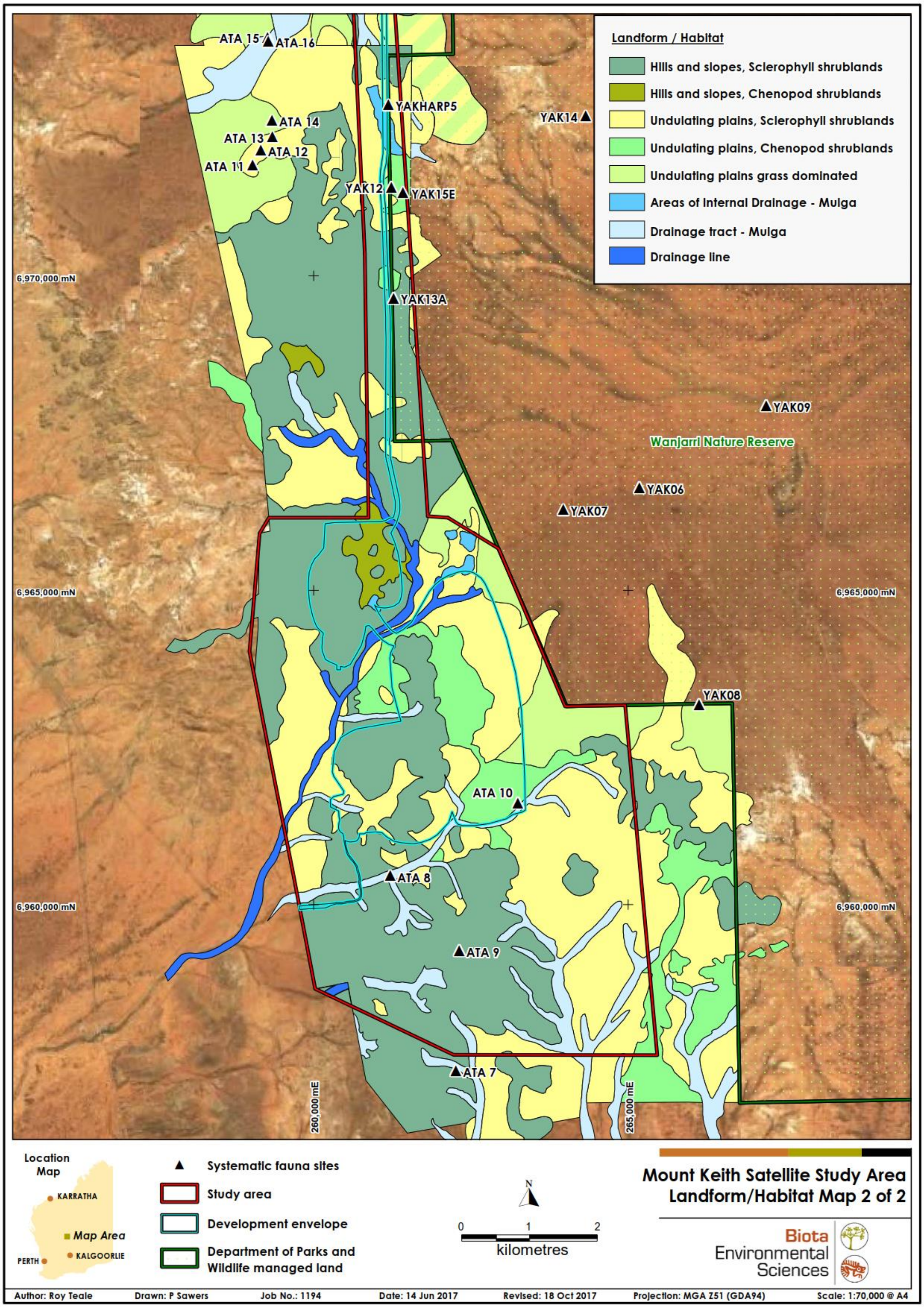


Figure 31 Landform/Habitat Map 2 of 2

Conservation significant species

Table 27 provides a summary of species with conservation ranking returned from database searches. For each of these species, an assessment of likelihood of occurrence has been made based on availability of suitable habitat, distribution and past records of the species. An assessment of risk to each conservation significant species has then been made, based upon this likelihood of occurrence, together with the scale of potential impact to habitat within the Study Area, and giving consideration to the wider availability of habitat.

Table 27 Conservation significant fauna risk assessment (Biota, 2017c)

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
Black-footed Rock-wallaby (*Petrogale lateralis lateralis*)			
Schedule 2 [endangered]	**Distribution** Known from a series of isolated, patchily distributed populations in Western Australia and Northern Territory (Pearson 2013, Woinarski et al. 2014). **Locality of records** Barr smith Range – South Albion Downs Borefield. **Recorded from Study Area** No. **Suitable habitat** Breakaway formations in Hills and Slopes, Sclerophyll Shrublands. The Development Envelope contains 3.9 ha of moderately prospective habitat representing approximately 1.4% of the occurrence of breakaway mapped in the local area (Figure 32).  Plate 1: Breakaway habitat from the Study Area (photo by Geoff Cockerton)	The Black-footed Rock-wallaby is known from a 2006 sighting 13.5 km west of the northern end of the transport corridor (Figure 32), which is significant as it appears to represent one of the only records from the Murchison bioregion. Following the 2006 sighting, collection and analysis of scats confirmed they were from Black-footed Rock-wallaby (Bamford 2015). During the recent targeted survey, scats consistent with rock-wallaby were again collected from the known locality, though few in number and aged, with no fresh scats identified. No additional rock-wallaby scats were found despite extensive searching of the breakaway landform. Numerous latrines are generally evident in the refuge areas of rock wallabies (Jarman and Caprararo 1997). Five camera traps were placed in areas of prospective habitat found within the Breakaway, including a camera at the location of the 2006 sighting and a camera within the Proposal transport corridor. Rock-wallaby was not recorded by any of the five cameras. The Black-footed Rock-wallaby is assessed as having a low likelihood of occurrence within the Study Area for the following reasons: • the lack of fresh evidence of rock-wallaby presence anywhere searched on the Barr Smith Range even from where the species was previously recorded; • no records on the camera traps anywhere on the range even in areas of most prospective habitat; and availability of higher quality habitat outside the Study Area than within.	The recent targeted survey indicated that the rock-wallaby does not occur within the Study Area. Further investigations did not find evidence of the species in the areas to the east or west of the Study Area. A small amount of potential non -core habitat will be disturbed by the proposal (3.9 ha). As a result of the low likelihood of occurrence and minor habitat impact, the risk to the subspecies is assessed as Low.

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
Brush-tailed Mulgara (*Dasycercus blythi*)			
DBCA Priority 4 [NA]	**Distribution** Patchy distribution throughout arid Queensland, Northern Territory and Western Australia. **Locality of Records** Widespread **Recorded from Study Area** No **Suitable Habitat** Undulating Plains Grass Dominated. An assessment of the habitat preferences of the Mulgara indicates that the Spinifex Sandplain unit of the Bullimore land system (Pringle et al. 1994) was their primary habitat (Halpern Glick Maunsell 2000).The Bullimore land system occurs widely throughout the region. Within the Study Area, 542.2 ha of potential habitat occurs of which 111.2 ha occurs within the Development Envelope (20.5%) (Figure 33)	Early records of the then Schedule 1 Mulgara from the Wanjarri Nature Reserve (Ecologia 1990) resulted in numerous Mulgara surveys being undertaken in the locality, particularly on Mt Keith, Albion Downs and Barwidgee Stations (Halpern Glick Maunsell 1997a, 1997b, 1999, 2000, Ecologia 1998, ATA 2005b, Biota 2006c). Reflective of this intensive survey effort, numerous populations of Mulgara have been recorded in the wider area (Figure 33). An individual was trapped at Site MKM01E in the Bullimore land system 500 m east of the transport corridor section of the Study Area and burrows, and tracks and scats of this species have been recorded from the Bullimore land system to the west of the transport corridor section of the Study Area (Biota 2006c).	While the species has been shown to occur within the Study Area, its habitat is much more widely distributed outside the Study Area and the Proposal is unlikely to impact on the conservation status of the species.
Long-tailed Dunnart (*Sminthopsis longicaudata*)			
DBCA Priority 4 [NA]	**Distribution** Inhabits rocky, rugged habitat form the Pilbara and adjacent upper Gascoyne region in the west, to the central Northern Territory and South Australia. **Locality of Records** Mt Keith and Albion Downs Borefield. **Recorded from Study Area** No. **Suitable Habitat** Hills and Slopes, Sclerophyll Shrublands. Records have come from plateaus near breakaways, and from scree slopes and rugged boulder-strewn screes. Within the Study Area, 65.1 ha of potential habitat has been mapped while the Development Envelope, contains 3.9 ha (6%).	A single individual was recorded from a site to the west of the Mt Keith Mine and within the Albion Downs Borefield (Biota 2010). This species may occur in the Study Area, with core habitat represented by the breakaway areas.	This species is relatively common where it occurs and the Study Area falls within its already known distribution. 4.1 ha of the species core habitat occurs within the Study Area. The species is more widely occurring outside the Study Area. The risk to the species from the Proposal is assessed as low.
Central Long-eared Bat (*Nyctophilus major tor*)			
Priority 4 [NA]	**Distribution** Range that encompasses the southern half of Western Australia and southwestern South Australia. **Locality of records** Yeelirrie. **Recorded from Study Area** No. **Suitable habitat**	The nearest known record of the species was found in BCE (2015) from Yeelirrie (65 km west).	The Proposal has been designed to avoid the riparian vegetation of the Jones Creek system and furthermore, the species has not been recorded in the local area. Risk to the Central Long-eared Bat has therefore been assessed as low.

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
	Drainage line; Areas of internal Drainage – Mulga The species preference for wooded habitats and trees large enough to support hollows and/or exfoliating bark. The riparian vegetation of the Jones Creek system provides suitable habitat for the species.		
Burrowing Bettong (*Bettongia lesueur graii*)			
Schedule 4 [Extinct]	**Distribution** The inland subspecies is now considered extinct on the mainland, however, the DBCA has undertaken translocations from offshore Islands and captive bred populations to Lorna Glen, located approximately 150 km northeast of the Study Area. **Locality of records** NA (Extinct) **Recorded from Study Area** No **Suitable habitat** Numerous old mounds are evident throughout the broader region, particularly in calcareous soils.	As the Burrowing Bettong is presumed extinct on the mainland (outside of re-introductions). It is highly improbable that this species occurs within the Study Area. Numerous old mounds are evident throughout the broader region, particularly in calcareous soils. This suggests that some habitat types may again be important for this species, should re-introductions succeed at locations like Lorna Glen.	The Proposal is located in the historical distribution of the species. The Proposal presents no risk at present, as the species is only present in reserves and islands.
Night Parrot (*Pezoporus occidentalis*)			
Schedule 1 [Endangered]	**Distribution** The Night Parrot is a small ground-dwelling Parrot endemic to Australia and occurring in arid to semi-arid regions where it requires dense, low vegetation, under or in which they hide during the day. **Locality of Records** Murchison bioregion (exact location unknown). **Recorded from Study Area** No **Suitable habitat** The current descriptions of the species' habitat preferences are broad, reflecting the wide variety of habitats the species was historically known from. The Department of Parks and Wildlife (2017) guideline details old-growth spinifex (*Triodia* spp.) as habitat for roosting and nesting as has been recorded in western Queensland (Murphy et al. 2017). Foraging habitats are broadly described as grasses and herbs that may or may not contain shrubs or low trees. Johnstone and Storr (1998) mention sparsely-wooded *Triodia* spp. near water as the habitat preferred by this species, while Pizzey and Knight (2007) list the following additional habitats: seeding spinifex on stony rises, breakaway country, sandy lowlands, shrubby glasswort, chenopods, succulents on flats around salt lakes, flooded claypans, saltbush, bluebush and bassia associations.	Targeted surveying for the species comprised of 56 nights of automatic sound recording across nine sites (six within the Study Area and three in the Wider Area) in potential roosting/nesting habitat together with 9.7 hours of targeted listening surveys. No evidence of the Night Parrot was recorded. The roosting/nesting habitat within the Study Area was considered to be marginally suitable for Night Parrot, and unlikely to support a resident population. Some potential feeding habitat is present in the Study Area, but it is widespread in the region and there are much better potential foraging locations elsewhere. Consequently the likelihood of Occurrence of Night parrot is considered to be very low.	Risk to both roosting/nesting habitat and foraging habitat was assessed as low due to the small area of habitat to be impacted by the Proposal and its marginal suitability for Night Parrot. Assessing the Proposal against the EPBC Act Significant Impact Guidelines (Department of the Environment 2013), it was concluded that none of the significant impact criteria would be met, and the adverse effects on potential core (roosting/nesting) habitat are localised and minor in scale.

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
	 Plate 2: Example of spinifex recorded from the transport corridor section of the Study Area (photo Geoff Cockerton). At the local (site) level, roosting and nesting sites are in clumps of dense vegetation, primarily old and large spinifex clumps (often >50 years unburnt), especially hummocks that are ring-forming. These may be in expanses or isolated patches, but sometimes associated with other vegetation types, such as dense chenopod shrubs. Using the broadest definition of potential roosting/nesting habitat as that containing spinifex, the wider area supports 55,430.7 ha, the Study Area supports 351.1 ha and the Development Envelope intersects a much smaller subset of this (36.7 ha) which represents 0.07% of the occurrence of this habitat type in the wider area. At the local (site) level, roosting and nesting sites are in clumps of dense vegetation, primarily old and large spinifex clumps (often >50 years unburnt), especially hummocks that are ring-forming. These may be in expanses or isolated patches, but sometimes associated with other vegetation types, such as dense chenopod shrubs. Potential foraging habitat within the Study Area was defined using those vegetation units comprising areas of Wanderrie Bank grassy shrublands, spinifex shrublands, bluebush shrublands and chenopod plains, which occur broadly across the Study Area and within the Development Envelope. The Study Area was mapped as containing 981.2 ha of potential foraging habitat of which 365.9 ha is intersected by the Development Envelope, which represents 0.5% in the wider area.		
Malleefowl (*Leipo ocellata*)			
Schedule 3 [Vulnerable]	**Distribution** Mallee fowl are mainly found in the semi-arid and arid zones of Australia in mallee dominated shrublands or low woodlands (Benshemesh 2007).	The Study Area occurs at the northern extreme of the Malleefowl distribution and records are sporadic. Records from both the DBCA and WA Museum confirm the presence of this species at Mt Keith and in the nearby Wanjarri Nature Reserve. Moriarty (1972) notes old mounds and tracks of	Whilst suitable habitat occurs within the Study Area, the proposal is likely to have limited impact on this habitat. Whilst tracks have been observed, surveys have not recorded the Mallee fowl in the

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
	The Mallee fowl was once broadly distributed across the southern half of the Australian continent, but has undergone significant range reduction over the past several decades. It is now restricted to the Southwest of Western Australia, and to southern areas of South Australia and New South Wales (Burbidge 2004, Garnett et al. 2011). Populations are scattered throughout the southern portion of mainland Australia with the largest section of contiguous habitat occurring east of the Wheatbelt in Western Australia. **Locality of records** Wanjarri Nature Reserve and numerous locations at Yeelirrie **Recorded from Study Area** No **Suitable habitat** Drainage line; areas of internal drainage – mulga The distribution of habitat within the Study Area represents 197.2 ha in total while the area within the Development Envelope is 16.2 ha (8%).	this species in Wanjarri Nature Reserve, Roy Teale (Biota) recorded tracks in the reserve in 1997, and Kylie McKay (BHBP) recorded tracks in the reserve earlier in 2017. The species is also known from Yeelirrie (BCE 2015).	Study Area. This risk to this species is considered to be low.
Peregrine Falcon (*Falco peregrinus*)			
Schedule 7 [NA]	**Distribution** The Peregrine Falcon has an almost cosmopolitan distribution, but is absent from most deserts and the Nullarbor Plain (Johnstone and Storr 2004). **Locality of records** Mt Keith, Wanjarri Nature Reserve. **Recorded from Study Area** No. **Suitable habitat** Drainage line. Areas of potential habitat for the Peregrine Falcon within the Study Area and wider area were mapped from the occurrence of breakaway and watercourses. Habitat for this species is widely occurring Proposal is unlikely to impact the status of the species. Vegetation units comprising breakaway (111.1 ha) and drainage tracts (339.9 ha) together comprise 451 ha within the Study Area	This species was recorded by Moriarty (1972), who reported seeing it occasionally in good seasons, and it has also been recorded over the Mt Keith mine office (Roy Teale, Biota, pers. obs.) and from the Barr Smith Range (BCE 2015). The species may periodically occur in the Study Area, particularly along drainage features and breakaways.	Very little core habitat for the species will be impacted by the Proposal and risk to it is therefore assessed as low.

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
	while 38.2 ha (0.4 ha breakaway and 37.8 ha drainage line) of this is within the Development Envelope.)		
Princess Parrot (*Polytelis alexandrae*)			
Priority 4 [NA]	**Distribution** This species occupies the eastern deserts of Western Australia, extending into South Australia. There are records from as far west as Wiluna, Wanjarri Nature Reserve, Sandstone and Laverton. **Locality of Records** Wanjarri Nature Reserve (unconfirmed) **Recorded from Study Area** No **Suitable habitat** Drainage Line; Areas of internal drainage – Mulga The vegetation units supporting Eucalypt woodland (EGPW), Mallee over spinifex (SAMA) and Hakea shrubland (GHPS) may represent potential habitat but very little occurs within the Study Area.	There has been one unconfirmed sighting of the Princess Parrot near Wanjarri Nature Reserve (Ms Leisa Turner, Environmental Advisor Mt Keith Operations, pers. comm. 2005). Moriarty (1972) collected one specimen from near the Wanjarri shearing shed in 1964. In multiple recent surveys, the species has not been recorded within the Study Area. The eucalypt dominated woodlands preferred by the species for roosting and nesting are absent from the Study Area; however, Princess Parrots are highly nomadic and could occasionally utilise spinifex seeding events for foraging.	This species is highly nomadic and may occur in the Study Area opportunistically for occasional incursions for foraging. The Proposal is not expected to impact on this species.
Striated Grasswren (*Amytornis striatus striatus*)			
Priority 4 [NA]	**Distribution** This species occurs from the central arid zone of Western Australia to the south-western Northern Territory and down through central South Australia, as well as in three small areas of Victoria and New South Wales. **Locality of Records** Wanjarri Nature Reserve. **Recorded from Study Area** No **Suitable habitat** Undulating Plains Grass Dominated. Potential habitat was mapped as those vegetation units comprising sandplains with spinifex and shrubs (SAMU, SAWS and SAWA), 197.2 ha occur within the Study Area with 16.2 ha of this intersected by the Development Envelope.	Both the DBCA and WA Museum database searches produced records of the Striated Grasswren from the vicinity of Mt Keith, including two from Wanjarri Nature Reserve. Moriarty (1972) considered the species "plentiful in Spinifex country". Craig and Chapman (Craig and Chapman 2003) recorded a single individual from spinifex habitat in the Wanjarri Nature Reserve. BCE (2015) did not record this species during studies at Yeelirrie, however there are records from that area.	The habitat within the Study Area is much more widely distributed in surrounding areas and very little occurs within the Development Envelope. The Proposal is assessed as representing low risk to the sub-species.

Status under the WC Act [EPBC Act]	Distribution and Suitable habitat units in Study Area	Likelihood of Occurrence	Risk Assessment
Great Desert Skink (*Liopholis kintorei)*			
Schedule 3 [Vulnerable]	**Distribution** Patchily distributed in the Great Sandy Desert, Gibson Desert and Tanami Desert. The western extremity of its range approaches the Mt Keith area. **Locality of Records** Kathleen Station. **Recorded from Study Area** No. **Suitable habitat** Undulating Plaints Grass Dominated.	Suitable habitat for this species is available throughout the Study Area. Both the DBCA and the WA Museum have a single record of an animal trapped at Kathleen Station. It is therefore possible that this species occurs in the Study Area, although this is considered unlikely.	This species is unlikely to occur in the Proposal area. The risk presented to it by the Proposal is assessed as low.

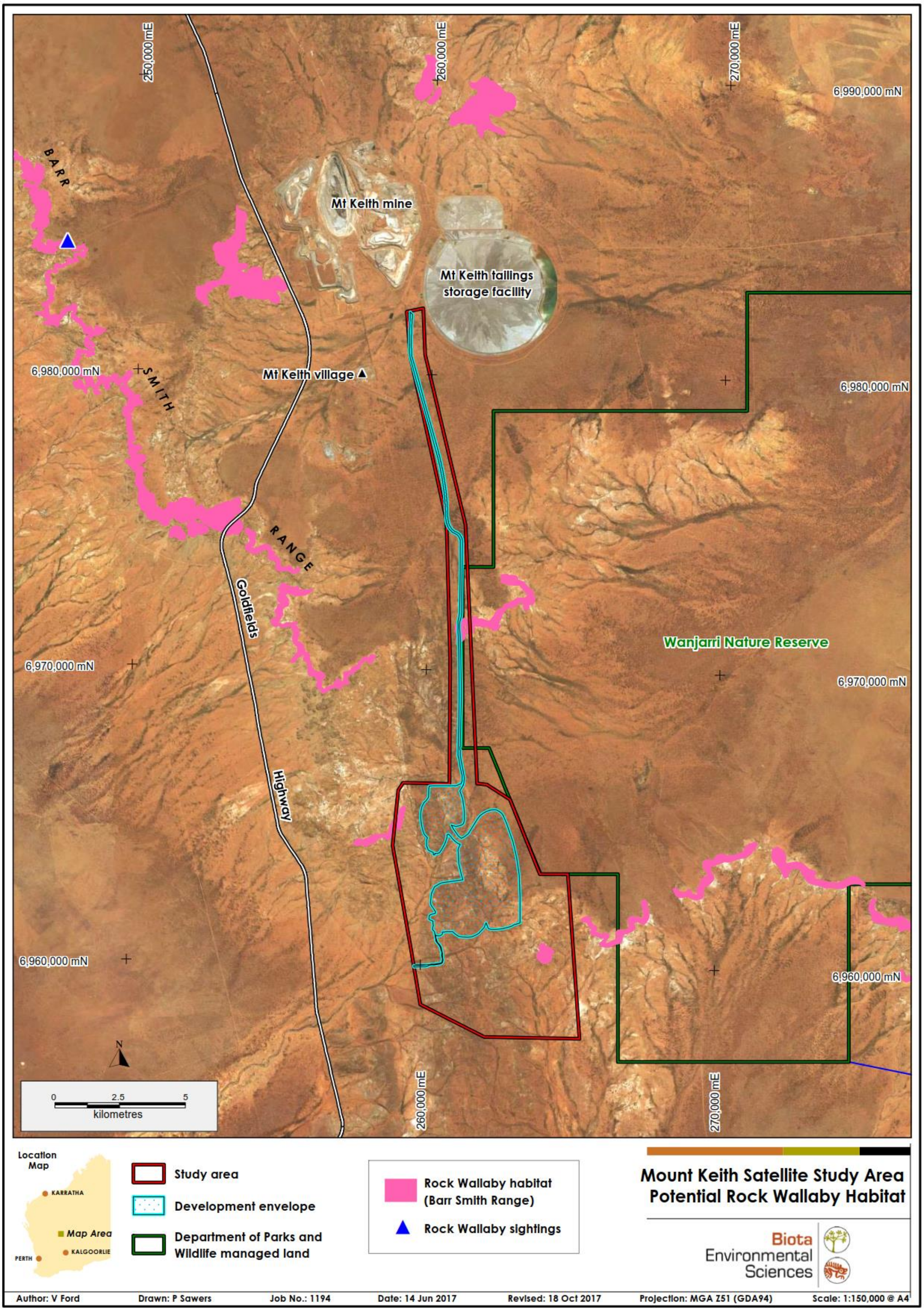


Figure 32 Potential Rock Wallaby Habitat

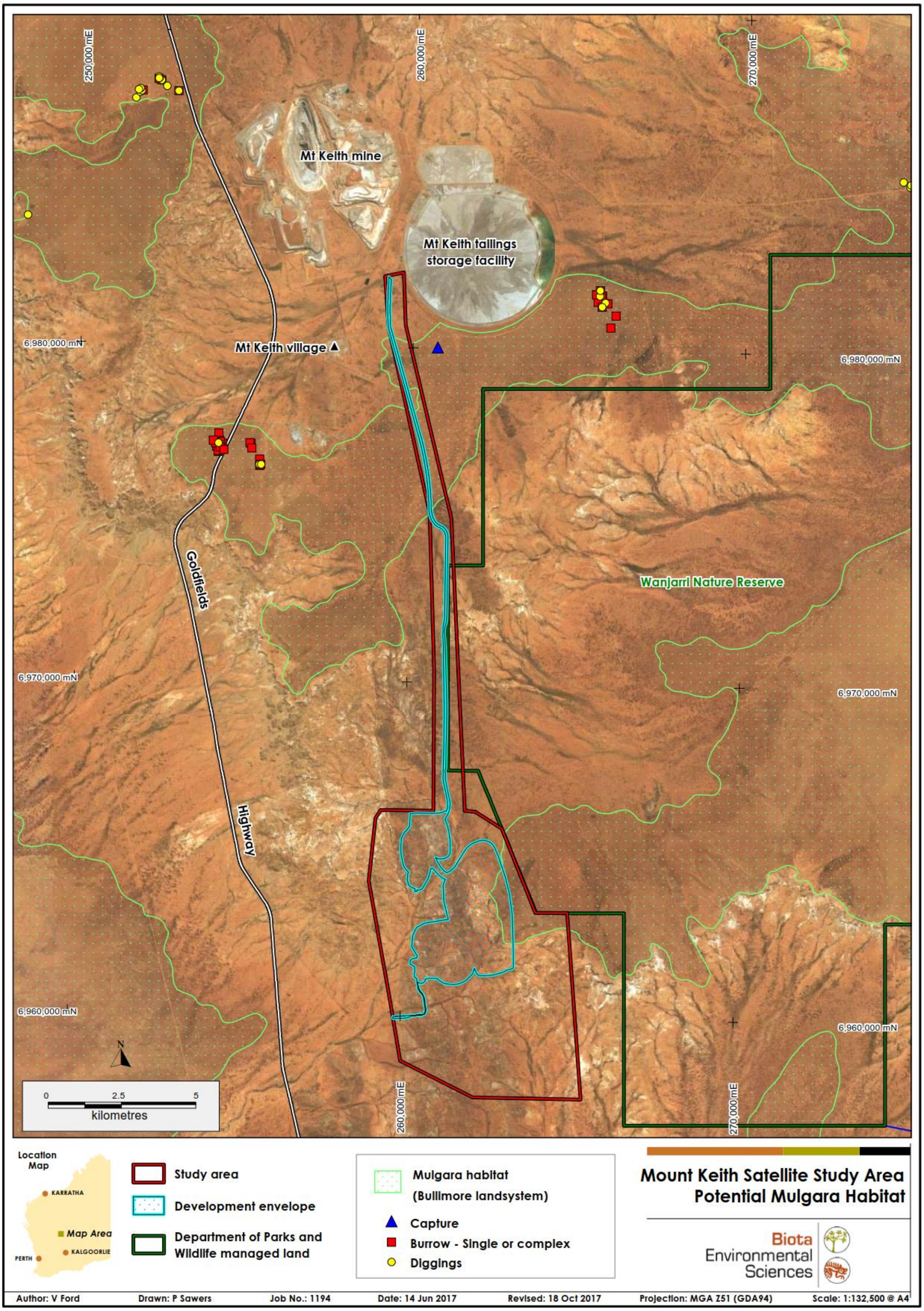


Figure 33 Potential Mulgara Habitat

Short range endemics (SRE)

Some invertebrate fauna groups are known to have species with small distribution (of less than 10,000 km2), within which the actual areas occupied may be small, discontinuous or fragmented. Furthermore, these species do not move outside their specific habitat due to poor dispersal ability, and consequently are more vulnerable to habitat changes and other impacts than more widely distributed taxa.

SRE Invertebratea Fauna Survey Effort

The Study Area and surrounds has been subjected to a number of SRE invertebrate fauna surveys, as listed in Table 28.

Table 28 SRE Invertebrate Fauna Surveys in the vicinity of the Study Area and key findings

Reference	Study details	Proximity to Study Area	Survey Methods	Broad habitats
(MWH 2016)	**Location:** The Study Area **Study Type**: Level 2 Terrestrial Short-range Endemic Invertebrate Fauna Assessment **Survey Date:** **Phase 1**: January – March 2011 **Phase 2:** March – April 2011 **Phase 3**: December 2011 – January 2012 **Phase 4**: February 2012 – March 2012	The Study Area	Wet pitfall trapping Targeted searching Litter collection Soil sieving Habitat mapping	9 broad fauna habitats including: Internal drainage Creekline Breakaway Mulga over Spinifex Sandplain Stony Hill and Slope Drainage Line Sparse Mulga Woodland Stony Plain Spinifex Sandplain
(Outback Ecology 2012a)	**Location:** Yakabindie: Lake Way South Borefield **Study Type**: Level 1 Terrestrial Short-range Endemic Invertebrate Fauna Assessment **Survey Date:** April 2011	Adjacent to and north of the Study Area	Targeted searching habitat mapping	8 broad fauna habitats including: Spinifex Sandplain Mulga over spinifex on sand plain Salt lake mosaic Sparse mulga woodland Kopi dune Sand dune Drainage Line Stony Hill and Slope
(Outback Ecology 2012b)	**Location:** Yakabindie: South East Borefield **Study Type:** Level 1 Terrestrial Short-range Endemic Invertebrate Fauna Assessment **Survey Date:** June 2012	Adjacent to and south of the Study Area	Targeted searching habitat mapping	8 broad fauna habitats including: Sparse Mulga Woodland Playa Drainage Line Mulga over Wanderrie grass Mulga over Spinifex on sandplain Stony Plain Calcrete plain Acacia shrubland Annual shrubland
Outback Ecology (2011)	**Location:** Lake Way **Study Type:** Wiluna Uranium Project: Terrestrial Fauna Assessment **Survey Date**: Autumn 2010	75 km north	Dry pitfall trapping Leaf litter collection Tullgren funnels, Soil sieving, Ultraviolet (UV) spotlighting and targeted searching	12 broad fauna habitats including: open Mulga woodland over spinifex Eucalypt woodland mallee/Mulga complex over spinifex

Reference	Study details	Proximity to Study Area	Survey Methods	Broad habitats
(Outback Ecology 2012a)	**Location:** Lake Way **Study Type:** Wiluna Uranium Project: Targeted Terrestrial Fauna Survey and Habitat Assessment **Survey Date:** March 2011	75 km north	targeted searching habitat mapping	12 broad fauna habitats including: Mallee/Mulga Complex over Spinifex, Melaleuca Stands Eucalypt Woodland
(Ecologia Environment 2011)	**Location:** Yeelirrie **Study Type:** SRE Invertebrate Fauna Baseline Survey **Survey Date:** **Searches**: July 2009 **Wet pitfall trapping**: Oct 2009 – Jan 2010 **Targeted survey:** March 2010.	50 km west-northwest	wet pitfall trapping, leaf litter collection, soil sieving and targeted searching.	8 broad habitats including: calcrete/calcrete outwash chenopod shrubland Breakaways hardpan Mulga shrubland of spinifex sandplain

Terrestrial SRE Invertebrate Fauna Habitats

The SRE surveys identified a total of nine broad habitats occurring within the Study Area, Targeted Survey Area and Wanjarri Nature Reserve, as shown in Figure 34 and Figure 35.

An assessment of the areas of each habitat within the survey areas and within the Study Area is presented in Table 29. Each of these habitats were broadly categorised as having a high, medium or low potential to support SRE species on the basis of forming sheltered microhabitats or by forming habitat isolates. Some areas of the Study Area used for this assessment extend outside of areas surveyed during the surveys. For these areas habitat mapping was extrapolated based on aerial imagery with reference to mapping from the Baseline Survey and the Targeted survey.

Table 29 Assessment of habitats and their potential to support SRE taxa (MWH, 2016)

SRE Invertebrate Fauna Habitat	Potential to support SRE species	Area (ha) of habitat					Habitat Description	SRE Species collected within habitat		
		Baseline survey area	Wanjarri Nature Reserve*	Targeted Survey Area	Study Area	Total Area Mapped^		# Confirmed taxa	# Likely taxa	# Potential taxa
Internal drainage	High	17.8	166.8	-	17.1	184.6	These areas of low elevation tend to form isolated, sheltered environments with elevated soil water content.		**1 pseudoscorpion:** Synsphyronus sp PSE023,	**3 spider:** Conothele sp., Aganippe sp. Anidiops sp **1 scorpion:** Urodacus cf gibson5 **4 pseudoscorpion**: Austrohorus sp., Beierolpium sp 8/3., Indolpium sp. Linnaeolpium sp **7 slaters:** Buddelundia 96., Buddelundia 45., Armadillidae sp indet., Armadillidae yakabindie a., Trichorhina sp indet., Cubaris yeelirrie1.
Creekline	High	77.2	-	251.2	76.7	251.2	Sheltered creek line with banked sides and unique riparian vegetation subject to ephemeral flows.	**2 millipedes:** Antichiropus 3., Antichiropus 2.	**1 slater:** Pseudodiploexochus yakabindie.,	**1 spider:** Aganippe sp **1 scorpion:** Urodacus cf gibson5 **5 pseudoscorpion:** Genus 7/4 sp. Austrohorus sp., Beierolpium sp 8/2., Beierolpium sp 8/3., Indolpium sp **3 slater:** Buddelundia 96., Philosciidae sp indet., Cubaris yeelirrie1.,
Breakaway	Medium	86.8	335.9	-	66.7	387.6	Breakaways provide sheltered areas that do not receive direct sunlight for much of the day. These habitats are isolated from other sheltered areas within the landscape.			**1 scorpion:** Urodacus cf gibson5, **2 pseudoscorpion:** Austrohorus sp., Linnaeolpium sp.,
Stony Hill and Slope	Medium	1818.7	18.3	431.3	1928.7	2157.5	Hill and slope were exposed for much of the day and provided limited sheltered areas for relictual species. However, the system of hill and slope in the Study Area is isolated from similar systems in the region.	**1 millipede:** Antichiropus 3	**1 spider:** Aname MYG235 **2 slater:** Armadillidae yakabindie b, Pseudodiploexochus yakabindie	**3 spider:** Conothele sp., Aganippe sp., Yilgarnia sp., **2 scorpion:** Urodacus cf Gibson 5., Lychas annulatus **5 pseudoscorpion:** Genus 7/4 sp., Austrohorus sp., Beierolpium sp 8/3, Indolpium sp., Linnaeolpium sp., **4 slater:** Buddelundia 96, Armadillidae sp indet, Philosciidae sp indet, Cubaris Yeelirrie 1.
Drainage Line	Medium	448.5	2958.1	70.8	496.2	3492.8	In general, drainage lines provide more shelter than surrounding habitats.		**1 slater:** Pseudodiploexochus_yakabindie	**2 spider:** Aganippe sp., Yilgarnia sp **1 scorpion:** Urodacus cf Gibson 5 **4 pseudoscorpion:** Genus 7/4 sp., Austrohorus sp., Beierolpium sp8/3., Indolpium sp **6 slater:** Buddelundia 96, Armadillidae sp indet, Armadillidae yakabindiea, Philosciidae sp indet, Cubaris Yeelirrie 2, Cubaris Yeelirrie 1.
Mulga over Spinifex Sandplain	Low	784.7	8147.1	13.2	417.2	8910.2	Leaf litter from Mulga trees provides an important habitat for species located within the Spinifex Sandplain habitat. However the habitat is relatively well represented in the surrounding landscape.		**1 slater:** Pseudodiploexochus yakabindie	**3 spider:** Idiosoma sp., Cethegus sp., Yilgarnia sp. **1 scorpion:** Urodacus cf Gibson 5, **5 pseudoscorpion:** Genus 7/4 sp., Austrohorus sp., Beierolpium sp 8/3, Indolpium sp., **5 slater:** Buddelundia 45, Armadillidae sp indet, Philosciidae sp indet, Cubaris Yeelirrie 2, Trichorhina sp indet,
Sparse Mulga Woodland	Low	1092.1	4868.1	906.3	1034.7	6603.6	Sparse Mulga Woodlands provide little shelter when compared to other habitats in the landscape.	**1 millipede:** Antichiropus 3	**1 slater:** Pseudodiploexochus yakabindie	**1 spider:** Anidiops sp **1 scorpion:** Lychas annulatus **4 pseudoscorpion:** Austrohorus sp., Beierolpium sp8/3, Beierolpium sp 8/4small, Indolpium sp. **6 slater:** Buddelundia 96, Buddelundia 45, Armadillidae sp indet, Armadillidae yakabindie a, Trichorhina sp indet, Cubaris Yeelirrie 1.
Stony Plain	Low	1349.0	13481.0	-	1292.8	14861.5	Stony Plains were exposed for much of the day and provided limited sheltered areas for relictual species. Additionally, they form a habitat that is extensive and contiguous in the landscape.		**1 slater:** Pseudodiploexochus yakabindie	**1 spider:** Aganippes p **1 scorpion:** Lychas annulatus **5 pseudoscorpion:** Genus 7/4sp., Austrohorus sp., Beierolpium sp 8/3, Indolpium sp., Linnaeolpium sp. **4 slater:** Buddelundia 96, Armadillidae yakabindiea, Philosciidae sp indet. Cubaris Yeelirrie 1.
Spinifex Sandplain	Low	-	22586.9	5.8	-	22598.4	The Spinifex Sandplain was exposed for much of the day and provided limited sheltered areas for relictual species. Additionally, they form a habitat that is extensive and contiguous within the Wanjarri Nature Reserve. This habitat does not occur within the Study Area but comprises over half of Wanjarri Nature Reserve.			
Disturbance (existing)	Low	-	-	--	91.8	91.8	Areas cleared for mining. Largely present in the northern portion of the Study Area.			
Totals		5675	52563	1679	5422	59539.2				

*Areas overlap the Study Area and Baseline Survey Area

^ Combined total of all areas surveyed (exclusing overlaps): Baseline Survey Area, Wanjarri Nature Reserve, Targeted Survey Area and Study Area

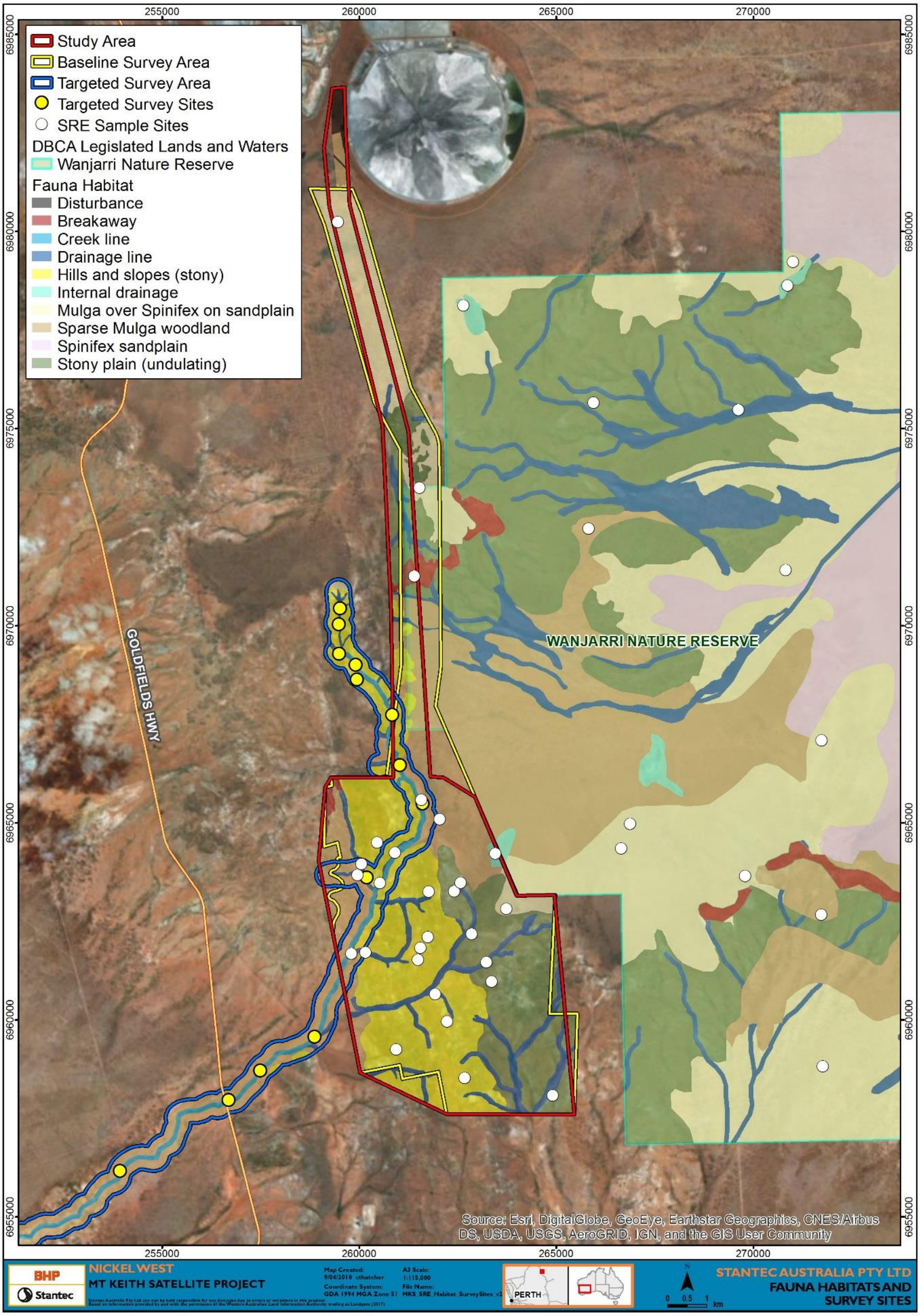


Figure 34 SRE Habitats combined across all surveys (Baseline Survey, Targeted Survey, Wanjarri Nature Reserve)

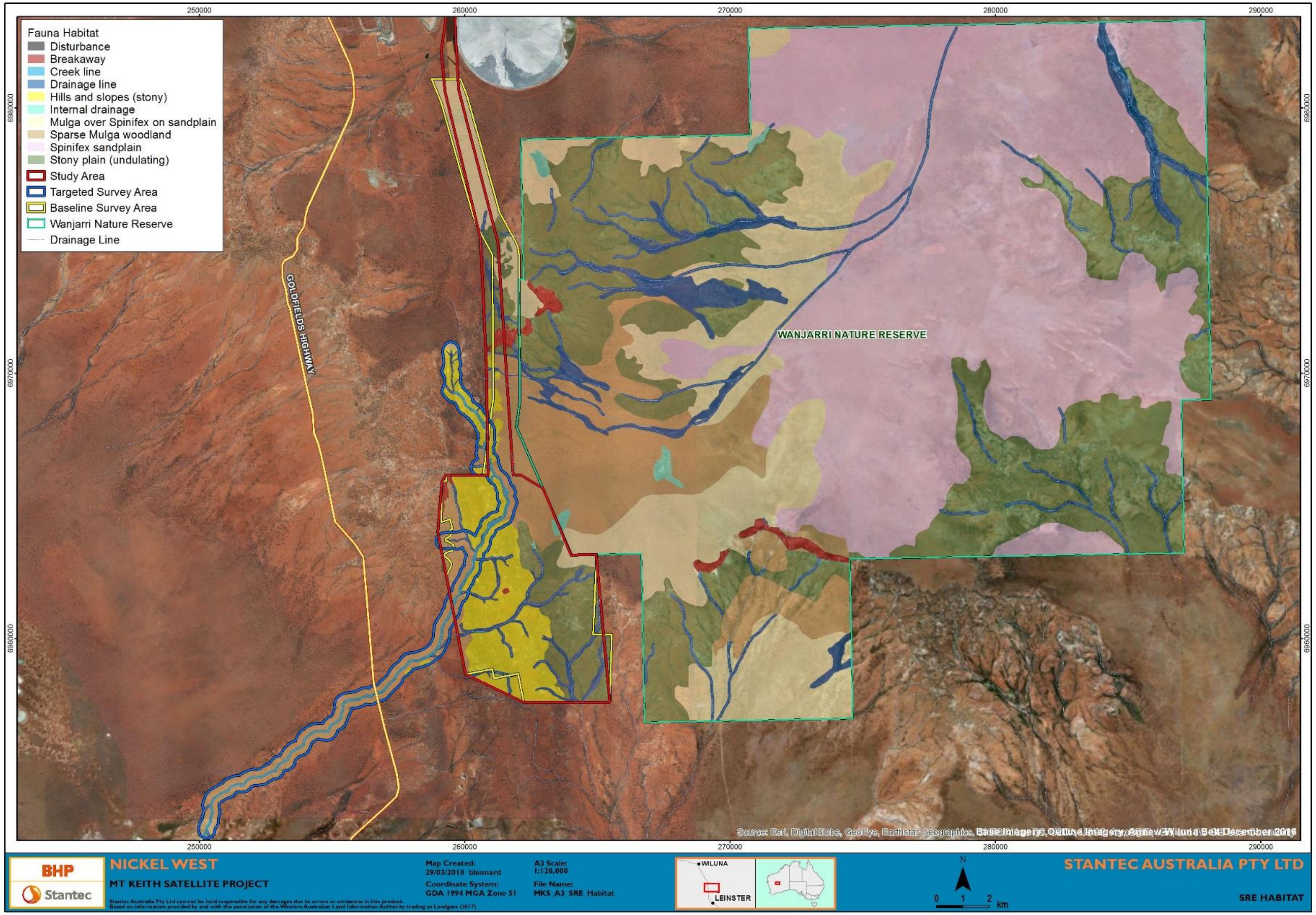


Figure 35 SRE Habitats within the vicinity of the Study Area

Terrestrial SRE Invertebrate Fauna

The surveys yielded a total of 1,682 invertebrate specimens from target groups from 49 species. Slaters were the most numerous group to be collected (832 specimens from 8 species), followed by pseudoscorpions (439 specimens from 11 species), scorpions (195 specimens from 9 species), mygalomorph spiders (168 specimens from 15 species), millipedes (38 specimens from two species) and snails (10 specimens from 4 species). Database and literature reviews identified an additional 42 potential SRE species occurring within 50 km of the Proposal. In total, based on the MWH (2016) study and previous studies, there are two Confirmed, four Likely and 25 Potential SRE species (23 from the survey and two from the desktop study) within the Study Area. These species are listed in Table 30 and locations in Figure 36 (MWH, 2016). None of the species recorded from within the Development Envelope were restricted to the Development Envelope.

Table 30 SRE species identified from the Study Area

SRE Status	Taxa	Group	Recorded within Development Envelope?	Recorded outside Development Envelope?
Confirmed	*Antichiropus 'DIP002'*	Millipede	Yes	Yes
	Antichiropus 'DIP003'	Millipede	No	Yes
Likely	*Aname 'MYG235'*	Mygalomorph spider	No	Yes
	Synsphyronus `sp. PSE023'	Pseudoscorpion	No	Yes
	Family Armadillidae 'yakabindie b'	Slater	No	Yes
	Pseudodiploexochus 'yakabindie'	Slater	Yes	Yes
Potential	*Aname 'Wanjarri* sp.1'**	Mygalomorph spider	No	Yes
	Idiosoma sp.*	Mygalomorph spider	No	Yes
	Cethegus sp.*	Mygalomorph spider	No	Yes
	Conothele sp.*	Mygalomorph spider	Yes	Yes
	Aganippe sp.*	Mygalomorph spider	Yes	Yes
	Anidiops sp.*	Mygalomorph spider	No	Yes
	Yilgarnia sp.*	Mygalomorph spider	Yes	Yes
	Urodacus cf 'gibson 5'	Scorpions	Yes	Yes
	Lychas annulatus	Scorpions	Yes	Yes
	Urodacus 'species A'**	Scorpions	No	Yes
	Genus 7/4` sp.*	Pseudoscorpion	Yes	Yes
	Austrohorus sp.*	Pseudoscorpion	Yes	Yes
	Beierolpium `sp. 8/2`	Pseudoscorpion	No	Yes
	Beierolpium `sp. 8/3`	Pseudoscorpion	Yes	Yes
	Beierolpium `sp. 8/4 small`	Pseudoscorpion	No	Yes
	Indolpium sp.*	Pseudoscorpion	Yes	Yes

SRE Status	Taxa	Group	Recorded within Development Envelope?	Recorded outside Development Envelope?
	Linnaeolpium sp.*	Pseudoscorpion	Yes	Yes
	Budddelundia 96	Slater	Yes	Yes
	Budddelundia 45	Slater	No	Yes
	Cubaris yeelirrie1	Slater	Yes	Yes
	Cubaris yeelirrie2	Slater	No	Yes
	Armadillidae yakabindie a	Slater	No	Yes
	Armadillidae sp. indet.*	Slater	Yes	Yes
	Philosciidae sp. indet.*	Slater	Yes	Yes
	Trichorhina sp. indet.*	Slater	No	Yes

* Species not identified to species or morphospecies

**Recorded as occurring in the Study Area during desktop study

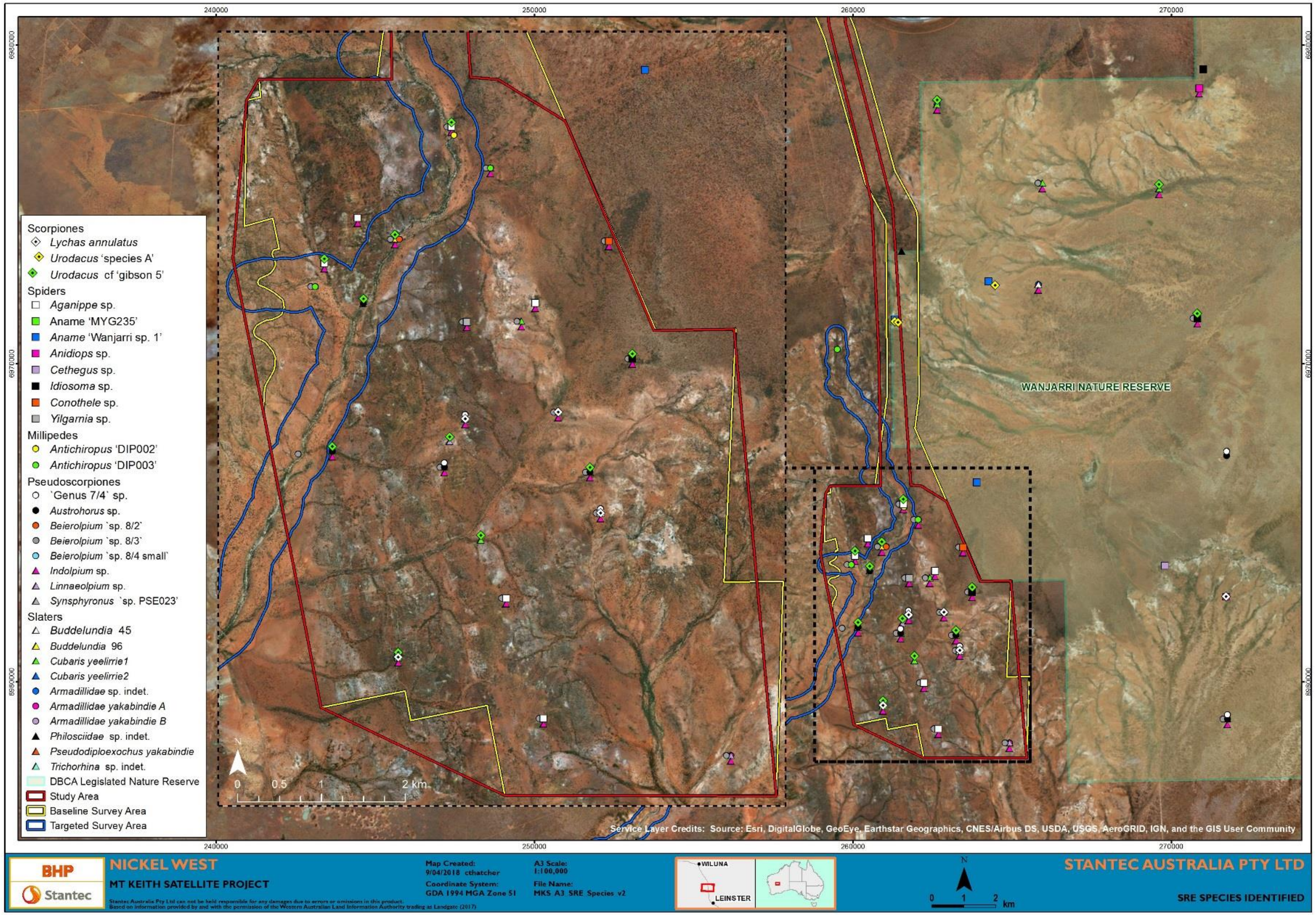


Figure 36 SRE Species collected from Study Area

6.3 Potential Impacts

The potential impacts and risks associated with terrestrial fauna as a result of the implementation of the Proposal, include:

- clearing of up to 878 ha of fauna habitats, including potential SRE invertebrate fauna habitat;
- clearing of potential habitat for conservation significant fauna, including Malleefowl and Black-flanked Rock-wallaby (also referred to as the Black-footed Rock-wallaby in this ERD);
- direct impacts to fauna from increased vehicle strikes, and as a result of construction and operation of the mine;
- potential to disrupt fauna habitat linkages;
- potential to introduce/attract feral animals; and
- disturbance to water birds (including migratory species, if present) from impacts to Jones Creek during construction of creek crossings.

6.4 Assessment of impacts

Terrestrial fauna are essential in maintaining the integrity and function of ecosystems. Many invertebrates, birds and mammals act as pollinators for plants, and help disperse plant seeds and fruit and spores of fungi. Fauna species can also be used as indicators of environmental health. Impacts to terrestrial fauna can be direct or indirect, and may be permanent or temporary. Direct impacts include the removal, fragmentation or modification of habitat, and mortality or displacement of individuals or populations (EPA, 2016b).

The key threatening processes associated with Proposal can be categorised as direct or indirect impacts. Direct impacts primarily occur through land clearing, whereas indirect impacts include altered fire regimes, introduced flora and changes to surface hydrology, increase in noise, vibration, artificial light and impacts of dust.

DIRECT IMPACTS

The largest potential impact on both terrestrial vertebrate fauna and SRE invertebrate is land clearing and associated loss of habitat and individual fauna death (as clearing progresses and they are unable to move away from clearing area).

Table 31 describes the potential loss of terrestrial vertebrate fauna habitat, based on the habitat types described for the Study Area (Section 5) in relation to suitable habitat for conservation significant fauna (Figure 37 and Figure 38). Based on the consideration of conservation at landscape function level, and the risk assessment provided in Table 31, two landscape features were identified by Biota (2017a) has having elevated value as habitat for conservation significant species:

- The breakaway feature (an extension of the Barr Smith Range) associated with both the Hills and Slopes, Sclerophyll Shrublands habitat (BRX – Breakaway Plateaux Mulga Shrublands vegetation type) and the Undulating Plains – Chenopod Shrublands habitat (BCP – Breakaway Chenopod Plains vegetation type) is considered to be potential habitat for the Black-footed Rock-wallaby and Long-tailed Dunnart.
- The area of isolated groved mulga (GRMU) within the Areas of Internal Drainage – Mulga habitat, as is intersected by the transport corridor, is the best example of this vegetation type in the locality, and is considered locally significant in the context of vertebrate fauna, predominantly avifauna.

Table 32 describes the potential direct impact to conservation significant terrestrial fauna habitat, associated with land clearing, and is based on loss of all vegetation within Development Envelope.

Table 31 Potential direct, indirect and cumulative impacts to terrestrial fauna habitats in the locality

				Potential Indirect Impacts Most Relevant to Each Fauna Habitat						
Habitat	**Conservation Significant Species Potentially Occurring in Fauna Habitat (Likelihood of Occurrence in Development Envelope)**	**Extent of Habitat in Study Area (Ha)**	**Direct Impact (Land Clearing) to Fauna Habitat in Development Envelope (Ha (%))**	**Fire**	**Changes to surface hydrology**	**Noise, vibration, light emission**	**Dust**	**Vehicle Strike**	**Introduced Species**	**Cumulative Impacts to Conservation Significant Fauna and Fauna Habitats**
Undulating Plains Grass Dominated	Brush-tailed Mulgara, *Dasycercus blythi* (recorded) Striated Grasswren, *Amytornis striatus striatus* (unlikely) Great Desert Skink, *Liopholis kintorei* (unlikely) Night Parrot, *Pezoporus occidentalis* (very low)	425.3	43.32 (10.2)	✓	✗	✓	✓	✓	✓	Cumulative impacts to these habitats are moderate in a local context; direct impacts resulting from clearing may lead to aggregated effects from cumulated indirect impacts. Clearing allows introduced weeds to proliferate, and dust may supress grass growth and cause vegetation to die. These impacts may in turn lead to an increased fire risk as a result of an increased fuel load, which can lead to an increase in predation pressure on native fauna as introduced fauna move into burnt landscapes. Clearing for road construction may also impact on conservation significant species twofold; species may be more vulnerable to vehicle strikes (when species move through habitats or bask on roads), and roads allow introduced fauna species easier access to native habitat areas, resulting in enhanced predation pressure. Although unlikely to be present within the development envelope, the Night Parrot, if present, may be impacted by noise, vibration and light emissions from construction and operation of the Proposal, which could displace populations and in turn result in vehicle strikes and predation by introduced fauna.
Undulating Plains with Chenopod Shrublands	Night Parrot *Pezoporus occidentalis* (very low likelihood)	369.5	231.55 (62.7)	✓	✗	✓	✓	✓	✓	
Undulating Plains with Schlerophyll Shrublands	Malleefowl, *Leipoa ocellata* (low likelihood)	1688.2	338.32 (20.0)	✓	✗	✓	✓	✓	✓	
Drainage Lines	Central Long-eared Bat, *Nyctophilus major tor* (unlikely) Princess Parrot, *Polytelis alexandrae* (unlikely) Peregrine Falcon, *Falco peregrinus* (may periodically occur)	97.9	22.28 (22.8)	✗	✓	✓	✓	✗	✓	Cumulative impacts to this habitat are moderate in a local context; clearing of vegetation for construction of creek crossings may cause increased weed growth. This may result in degradation of riparian habitats in waterways within the development envelope and beyond if weed seeds are transported via surface water flow to downstream drainages. This impact may be compounded by increased sedimentation from mining activities causing degradation of waterways. The potential degradation of riparian habitats may add to local habitat loss from direct impacts of clearing, which could displace conservation significant species that may use these habitats.
Areas of Internal Drainage- Mulga	No conservation significant vertebrate fauna species likely to rely on the habitat but supports relatively high biodiversity particularly of birds. Also represents some of the best potential habitat for invertebrate including potential SRE species.	119.2	14.69 (12.3)	✓	✓	✓	✓	✗	✓	Cumulative impacts to this habitat are moderate in a local context. The groved mulga in the locality is considered locally significant as it is not common. Impacting factors are both direct (clearing 14.69 ha), while fire and alteration to surface flows have the highest potential to remove further habitat of this type.
Drainage Tract - Mulga	No conservation significant vertebrate fauna species likely to rely on the habitat but supports relatively high biodiversity particularly of birds. Also represents some of the best potential habitat for invertebrate including potential SRE species.	417.3	32.38 (7.8)	✓	✓	✓	✓	✗	✓	Cumulative impacts to this habitat are moderate in a local context. The groved mulga in the locality is considered locally significant as it is not common. Impacting factors are both direct (clearing 32.38 ha), while fire and alteration to surface flows have the highest potential to remove further habitat of this type.
Hills and Slopes with Chenopod Shrublands	No conservation significant vertebrate fauna species likely to rely on the habitat.	74.6	63.43 (85.0)	✓	✗	✓	✓	✓	✓	A high proportion of these habitats occur within the development envelope. Clearing is likely to cause increased weed growth, in turn leading to enhanced fire risk. Dust from haul roads is likely to cover vegetation, which could cause die-offs if not managed.
Hills and slopes, Sclerophyll shrublands	Malleefowl, *Leipoa ocellata* (low likelihood)	2090.5	510.25 (24.4)	✓	✗	✓	✓	✓	✓	
Breakaway formations in hills and slopes, Sclerophyll shrublands	Black-footed Rock-wallaby, *Petrogale lateralis lateralis* (unlikely) Long-tailed Dunnart, *Sminthopsis longicaudata* (may potentially occur in habitat adjacent to Development Envelope) Peregrine Falcon, *Falco peregrinus* (may periodically occur)		Does not occur within Development Envelope	✗	✗	✓	✗	✓	✓	Cumulative impacts to this habitat are minimal in a local context; this habitat occurs in a very small percentage of the development envelope and is well represented regionally. Therefore, impacts derive from direct habitat loss as a result of clearing. Species such as the Black-footed Rock-wallaby and Long-tailed Dunnart, if present, may move through the study area and may be susceptible to vehicle strikes and/or predation by introduced vertebrate species. Caves present in the Barlee Range are likely to support bats, which can be susceptible to vibration, noise and light effects.
	TOTAL	**5282.5**	**1256.2**							

Table 32 Potential terrestrial vertebrate fauna habitat loss due to land clearing

Habitat suitable for conservation significant fauna	Area within Development Envelope (ha)	Area of habitat in Study Area ha)	% habitat in Study Area
Hills and Slopes, Sclerophyll Shrublands	3.9	65.1	6
Undulating Plains Grass Dominated	111.2	542	20.5
Areas of Internal Drainage – Mulga / Drainage Line (includes Jones Creek)	16.2	197.2	8.2
Sandplains with spinifex and shrublands (SAMU, SAWS, SAWA)	16.2	197.2	8.2

Despite significant fauna survey efforts, no conservation significant terrestrial vertebrate species have been definitively identified within the Development Envelope. Furthermore, the available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of conservation significant species.

Table 33 describes the potential loss of SRE invertebrate fauna habitat (MWH, 2016) associated with clearing of native vegetation, and is based on worst-case scenario of loss of all vegetation within Development Envelope.

Table 33 Potential SRE invertebrate fauna habitat loss from land clearing

SRE Invertebrate Fauna Habitat	Potential to support SRE species	Area within Development Envelope (ha) *Worst case scenario*	Area of habitat in Study Area (ha)	% Development Envelope Habitat in Study Area	Total area of habitat mapped* (ha)	% Area within Development Envelope in total area of habitat mapped*
Internal drainage	High	2.5	17.07	14.6	184.6	1.4
Creekline	High	3.5	76.68	4.5	251.2	1.4
Breakaway	Medium	6.4	66.73	9.7	387.6	1.7
Stony Hill and Slope	Medium	656.6	1928.67	34.0	2157.5	30.4
Drainage Line	Medium	69.2	496.21	13.9	3492.8	2.0
Mulga over Spinifex Sandplain	Low	18.1	417.4	4.3	8910.2	0.2
Sparse Mulga Woodland	Low	147.5	1034.69	14.3	6603.6	2.2
Stony Plain	Low	211.3	1292.83	16.3	14861.5	1.4
Spinifex Sandplain	Low	-	0.0	-	22598.4	-
Disturbance (existing)	Low	91.82	-	-	91.8	100.0
Total		1115	5422	21.0	59539.2	1.9

* Combined total of all areas surveyed (exclusing overlaps): Baseline Survey Area, Wanjarri Nature Reserve, Targeted Survey Area and Study Area

With respect to potential impacts from the Proposal to SRE taxa; one confirmed, one Likely and 14 Potential SRE species have been collected from within the Development Envelope. However, none of these species have been collected exclusively from within the proposed Development Envelope. All species collected within the Development Envelope for the Proposal have also been collected outside this area, meaning that no single species is restricted to the Development Envelope. Figure 37 depicts the impacts to SRE species within the Development Envelope.

All of the identified habitats, excluding Spinifex Sandplain were identified within the Study Area for this assessment. With respect to SRE species, the Creekline and Internal Drainage habitats have a high potential of supporting SRE species (Figure 38). Approximately 4.5% of Creekline and 14.6% of Internal Drainage habitat within the Study Area will be directly impacted upon by the Proposal. From the Baseline and Targeted surveys, it is known that additional Creekline habitat and Internal Drainage habitat occurs outside of the Study Area and will not be directly impacted by the Proposal (MWH 2016b).

Within the total area mapped for this study, 1.4% of Creekline habitat and 1.3% of Internal Drainage Line habitat will be directly impacted by the Proposal. Secondary impacts to the Creekline habitat are likely to be minimal, provided that adequate controls of secondary impacts downstream of the Proposal are implemented and managed appropriately. Breakaway, Stony Hills and Slopes and Drainage Line habitats were considered to have a medium potential of supporting SRE species. Of these, the Proposal will have the largest impacts on the stony hills and slope habitat, where 34 % of this habitat in the Study Area will be impacted upon by the Proposal. No invertebrate habitat was found to be restricted exclusively to the proposed Disturbance Footprint. The Development Envelope largely comprises habitats with a medium or low potential to support SRE species (MWH 2016a). As a result, it is considered that the Proposal presents a low risk to SRE species.

INDIRECT IMPACTS

Implementation of the Proposal from construction to operation and closure, has the potential for indirect impacts beyond land clearing, including altered fire regimes; introduced flora; changes to surface hydrology; increase in noise, vibration, artificial light, impacts of dust and vehicle impact.

Fire

Increased human activity is correlated with increased fire risk and/or altered fire regimes. The potential for altered fire regime is discussed in Section 5. Fire can lead to temporary destruction of fauna habitat or more lasting degradation due to increased intensity and/or frequency, reduced food sources and increase in predation. SRE invertebrate habitats such as rocky outcrops are often fire refuges (EPA 2016c) which may not be burnt with the frequency of the surrounding landscape. The Study Area contains breakaway habitat which has the potential to provide fire refuge. Increasing fire frequency in fire refuges is likely to be detrimental to SRE invertebrates which have evolved in the absence of fire (MWH, 2016).

The likelihood of fire in the Proposal area is naturally low due to arid climate and low natural fire frequency. Mining activities have the potential to introduce sources of ignition through hot work and other activities; however, these can be actively managed by fire and emergency management procedures currently used by NiW at NMK. As discussed in Section 5, the introduction of additional mining activities, including the clearing of native vegetation, is unlikely to increase or alter the existing fire regime within both the local and regional context.

Changes to surface hydrology

The main drainage feature in the Study Area is Jones Creek, which aligns with the Creekline habitat, and is highly ephemeral first order stream which is incised into the Barr-Smith Range. Within the creek, water flows from the north through the Study Area and then to the southwest with the terminus for the creek as a floodplain containing a number of claypans (MWH 2016b). The creekline habitat is important for both conservation significant vertebrate and SRE invertebrate fauna. In particular, this habitat is known to support the two confirmed SRE species (*Antichiropus 'DIP002' and Antichiropus 'DIP003'*).

The Proposal requires the construction of two causeways across the creek to facilitate the transport of waste to the waste landform and to transport ore to Mt Keith for processing (Figure 4). Construction of the causeways will result in direct disturbance during construction. The remaining riparian vegetation will remain undisturbed.

Sediment may be carried into the creek as runoff from the waste rock landform and from areas that have been cleared for the Proposal following rainfall events. Higher sediment loads in surface water runoff may result in sedimentation downstream.

Noise and vibration, and light emissions

Noise and vibration from the Proposal will be associated with blasting, heavy vehicles and machinery associated with the mining operation, which will vary in intensity and duration according to the different phases of the Proposal. Light emissions will be associated with mining and haulage operations. Light emissions may be advantageous to some species, for example those that feed on insects around lights. Noise and vibration emissions may be disruptive to others whose communication may be disrupted by artificial background noise (e.g. the echolocation process of bats may be disrupted).

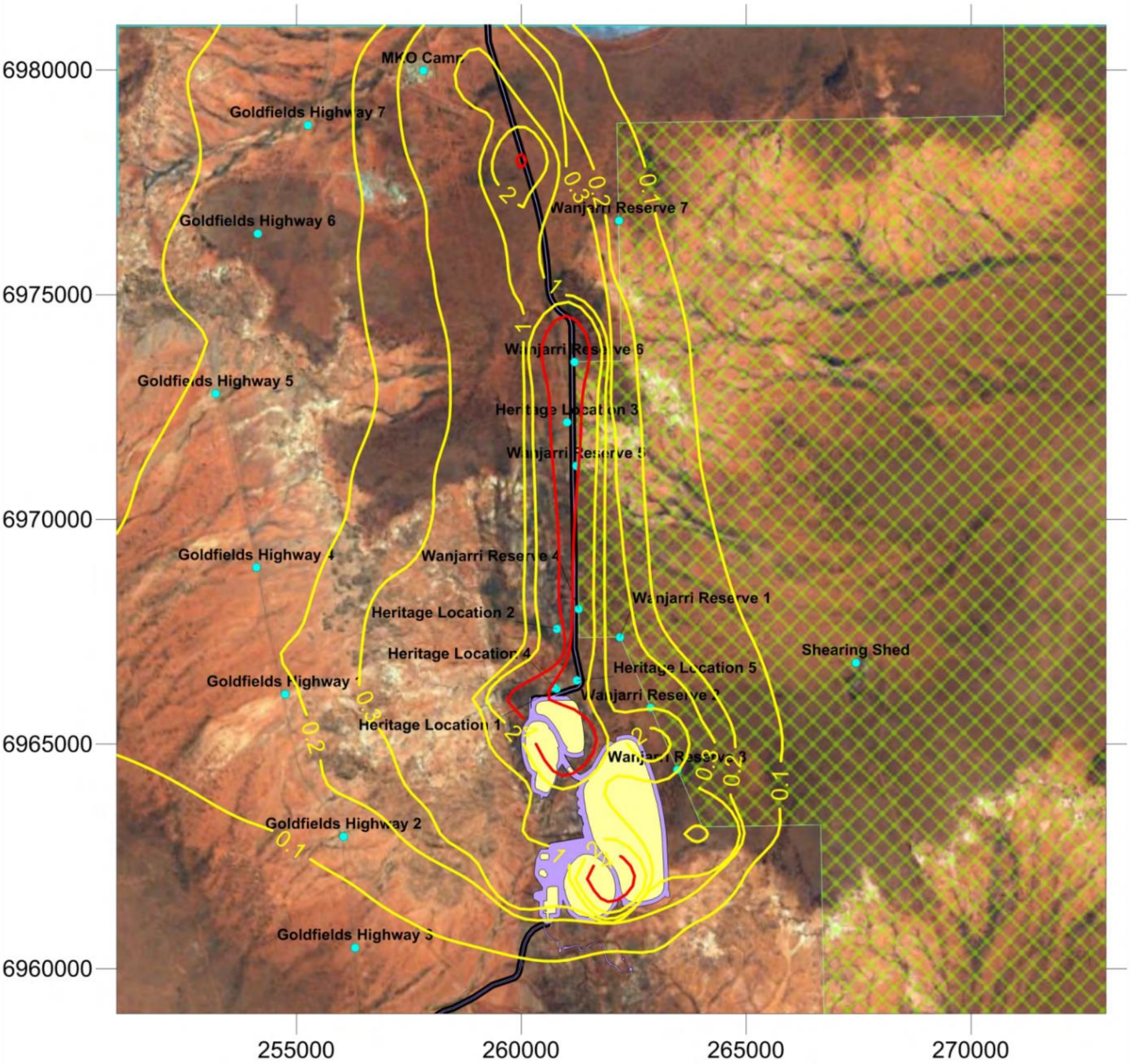
Regardless of the Proposal phase, noise and vibration may cause some vertebrate fauna species to move away from the area, alter their behaviours or change community structure. Information on the potential effects of noise, vibration and light emissions on SRE species limited and without further research, it is not possible to predict and quantify the potential impacts on SRE species (MWH 2016a).

With respect to vertebrate fauna, over time it is expected that most species will either habituate to light, noise and vibration associated with mining operations or move to a suitable distance away from the source so that they are no longer disturbed (Larkin, 1996). SRE species are unable to move significant distances to avoid disturbances such as light, noise and vibration. Most SRE invertebrate fauna in the eastern Murchison are active during the hours of darkness and it is possible that artificial light may influence feeding and breeding behaviours. Whilst the Proposal will be operating on a 24 hour basis, lighting will be limited to illumination of operational areas for safety requirements, primarily being the pit floor (which will move to below ground surface) and ROM pad, and vehicle lights.

Noise, vibration and light emissions are likely to dissipate rapidly with distance from the source and are not considered to be of significant risk to SRE species at either a local, or regional, scale.

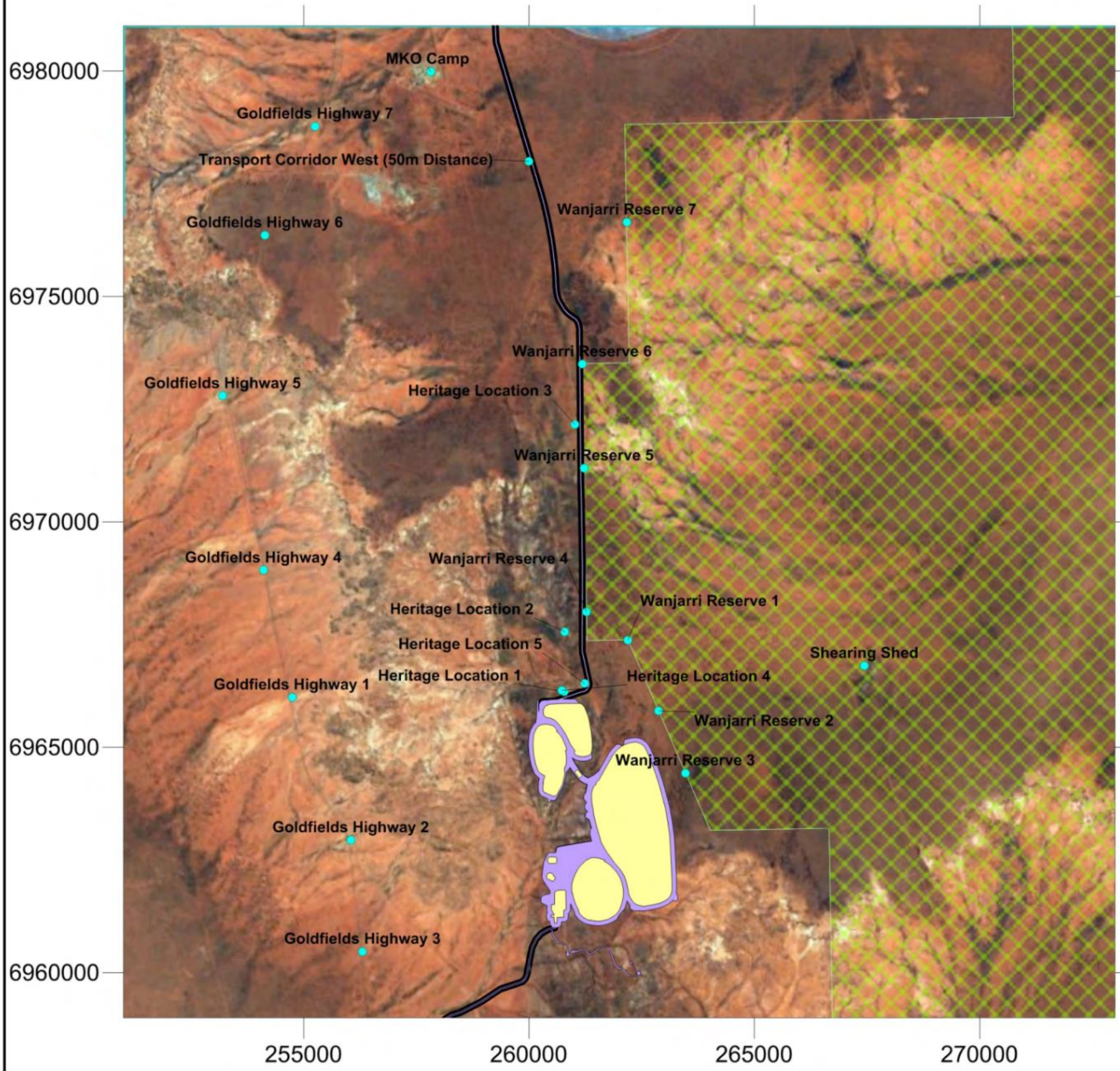
Dust

As described in Section 5, dust emissions may result in localised impacts on vegetation to the extent that faunal assemblages are affected through a reduction in both food and habitat resources. Localised dust emissions will be generated during all phases of the Proposal, with the greatest impact likely during construction when clearing of vegetation and topsoil occurs. The dust modelling, has indicated that due to the prevailing winds being easterly or south-easterly, the greatest deposition rates are expected to occur on the western side of the transport corridor. However, dust deposition rates can be maintained within acceptable levels for vegetation maintenance via the use of water-based suppression on the haul road and within the pits, as shown in Figure 39 (no dust control on haul road) compared to



Scenario 2 – TSP Predicted Deposition (g/m²/month)	Client: BHP Billiton Nickel West Pty Ltd	RAMBOLL ENVIRON	
	Project: MKSO Dust Modelling Assessment	Source: BHP Billiton	Date: Mar 2017

Figure 40 and



Discrete Receptor Locations	Client: BHP Billiton Nickel West Pty Ltd	RAMBOLL ENVIRON	
	Project: MKSO Dust Modelling Assessment	Source: BHP Billiton	Date: Mar 2017

Figure 41 (predicted dust deposition after dust suppression). Habitats with potential to be influenced by the higher concentrations of dust mostly comprise the two habitats: Stony Hills and Slopes and

Sparse Mulga Woodland. Smaller areas of the following habitats also occur within the areas with potential to be affected by dust Stony Plain, Mulga over Spinifex on Sandplain, Drainage Line and Breakaway habitats.

Vehicle strike

The operation of heavy machinery and vehicles on the haul road and access tracks within the Development Envelope will increase the likelihood for impact with native fauna. Small reptiles may be injured or killed on roads whilst basking during the day and mammals may be impacted particularly at dawn and dusk. Injured or dead animals attract scavenging species, which then are more likely to be struck themselves. Given that short range species are largely restricted to the immediate vicinity of their habitat, impact due to vehicle strike is likely to be minimal.

Noise and vibration emissions from machinery and vehicles may assist to deter some species from transportation routes. Ground-dwelling species are at greatest risk of vehicle strike including the Malleefowl, Brush tailed Mulgara, Long-tailed Dunnart and Great Desert Skink. The overall risk to vertebrate fauna is low and unlikely to result in a change of conservation status.

Short range species are largely restricted to the immediate vicinity of their habitat, therefore impact due to vehicle strike is likely to be minimal.

Introduced species

The introduction and spread of feral animals and weeds through increased human activity and disturbance could result in changes to species composition, fire frequency and abundance of native communities.

Weeds can significantly alter the vegetation of a fauna habitat where infestations occur, resulting in significant declines in species richness or diversity of local fauna. Introduced flora (weed) species may be spread as a result of mobile mining equipment, ground disturbance, construction and ongoing activities of the Proposal.

Introduced fauna species may impact native fauna through a range of factors, including predation, competition for food and shelter, habitat destruction and the spread of diseases. Putrescible waste and artificial water points around camps, offices and crib rooms could attract both native and introduced animals. Apart from the physical threats (entangling in packing material, bottles and cans), animals could also be more vulnerable to introduced predators and road accidents.

Implementation of feral animal and weed control measures will be required to ensure that introduced species do not significantly impact on local terrestrial fauna.

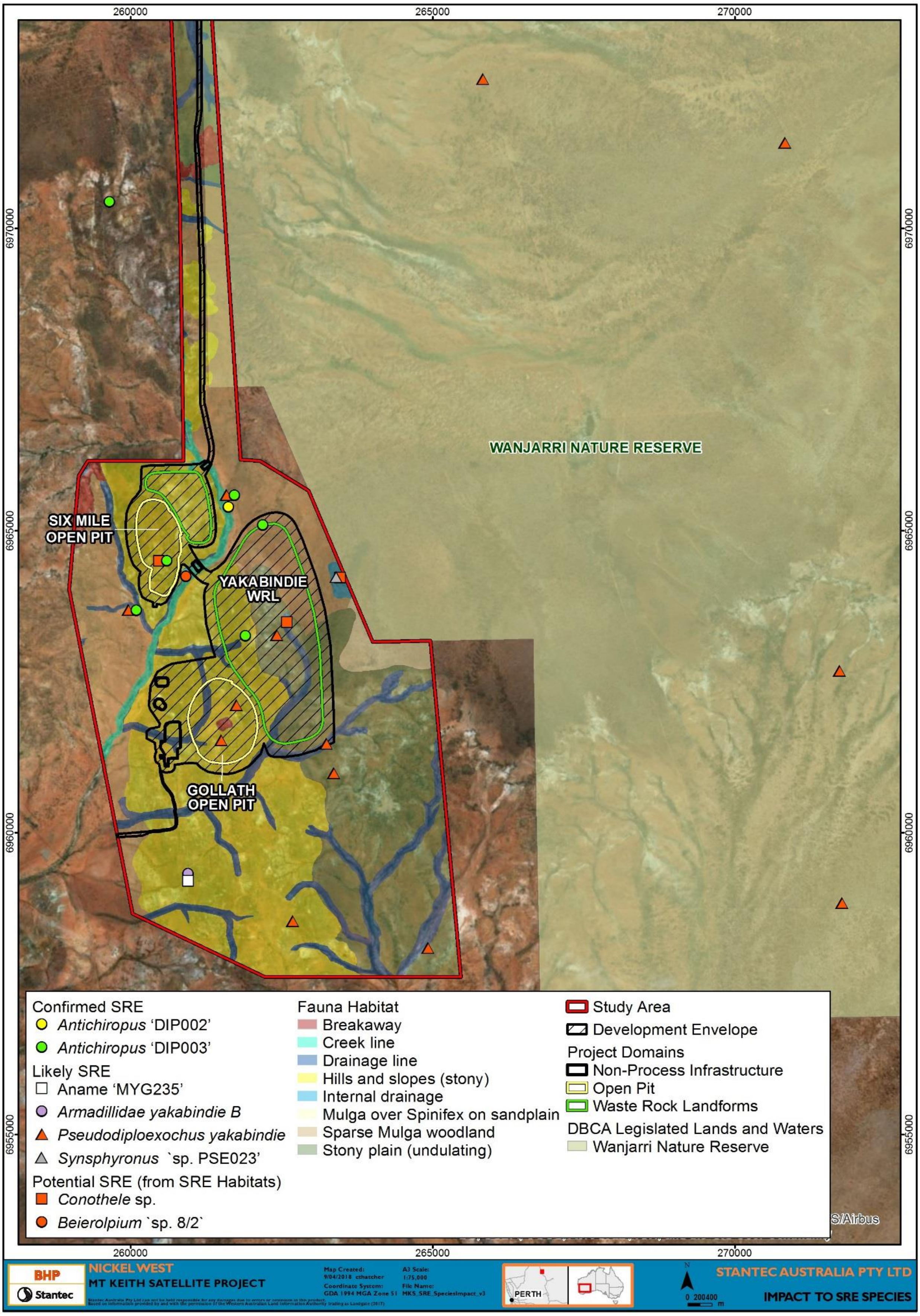


Figure 37 MKS Impacts to SRE Species in Development Envelope

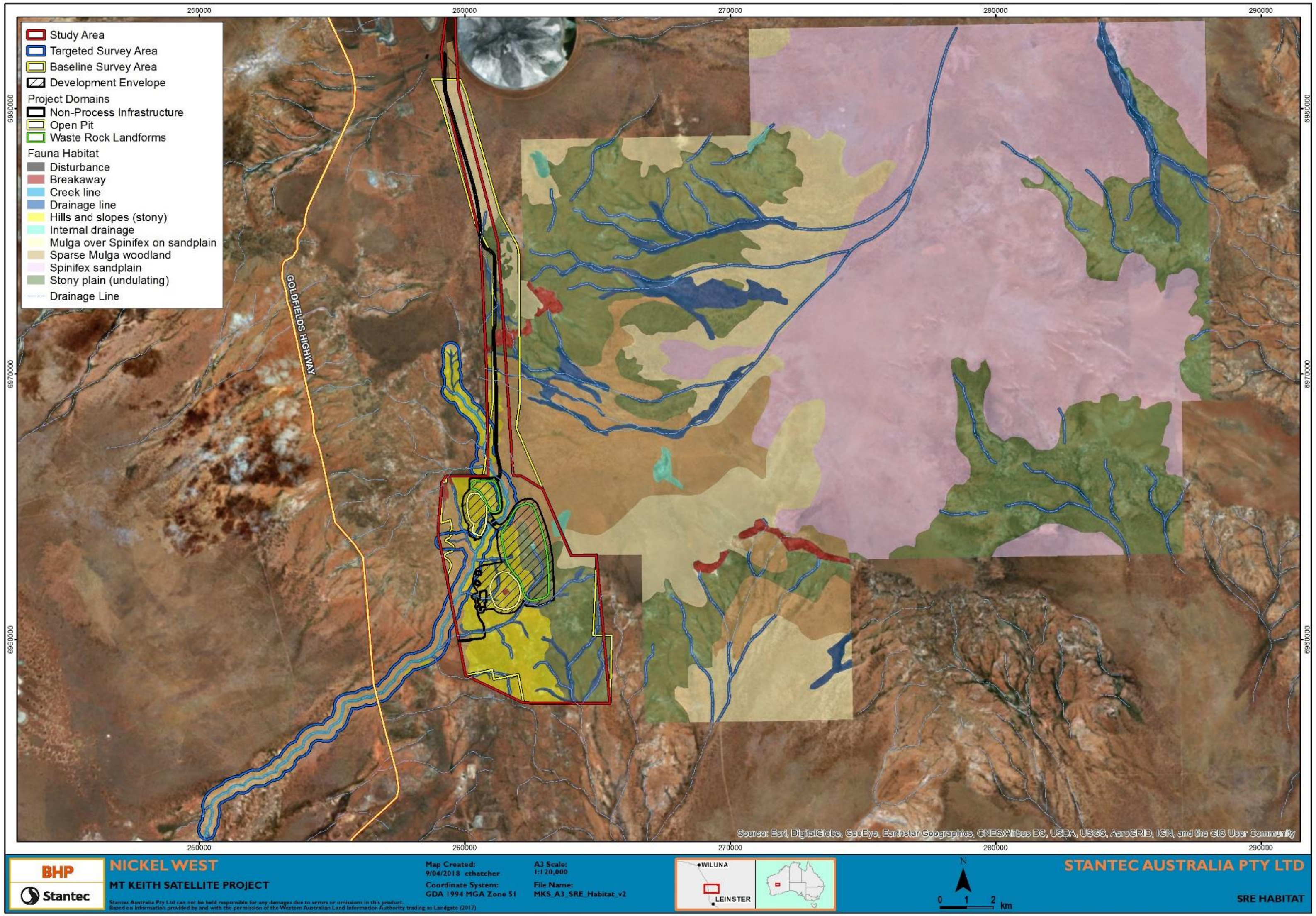
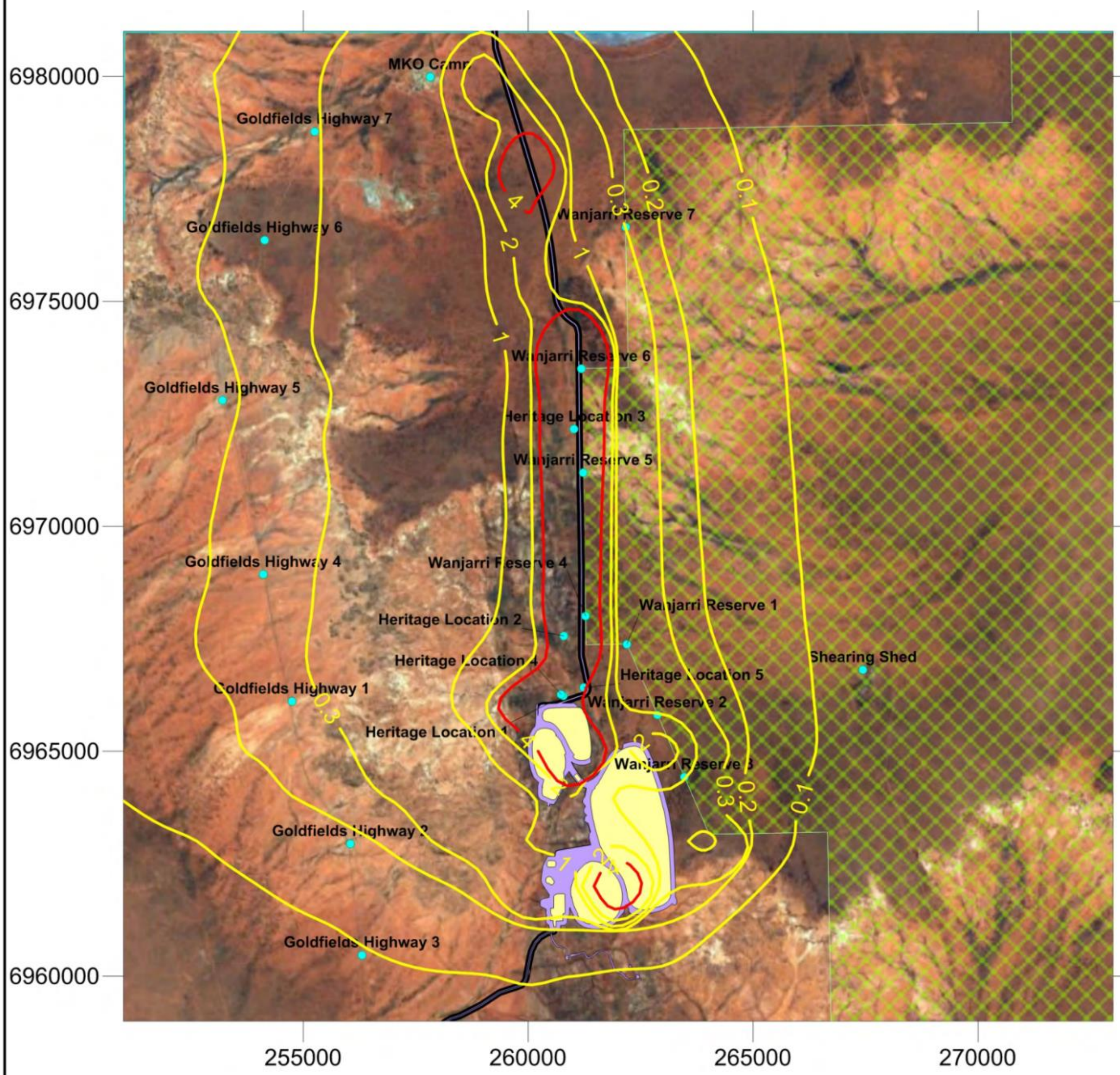
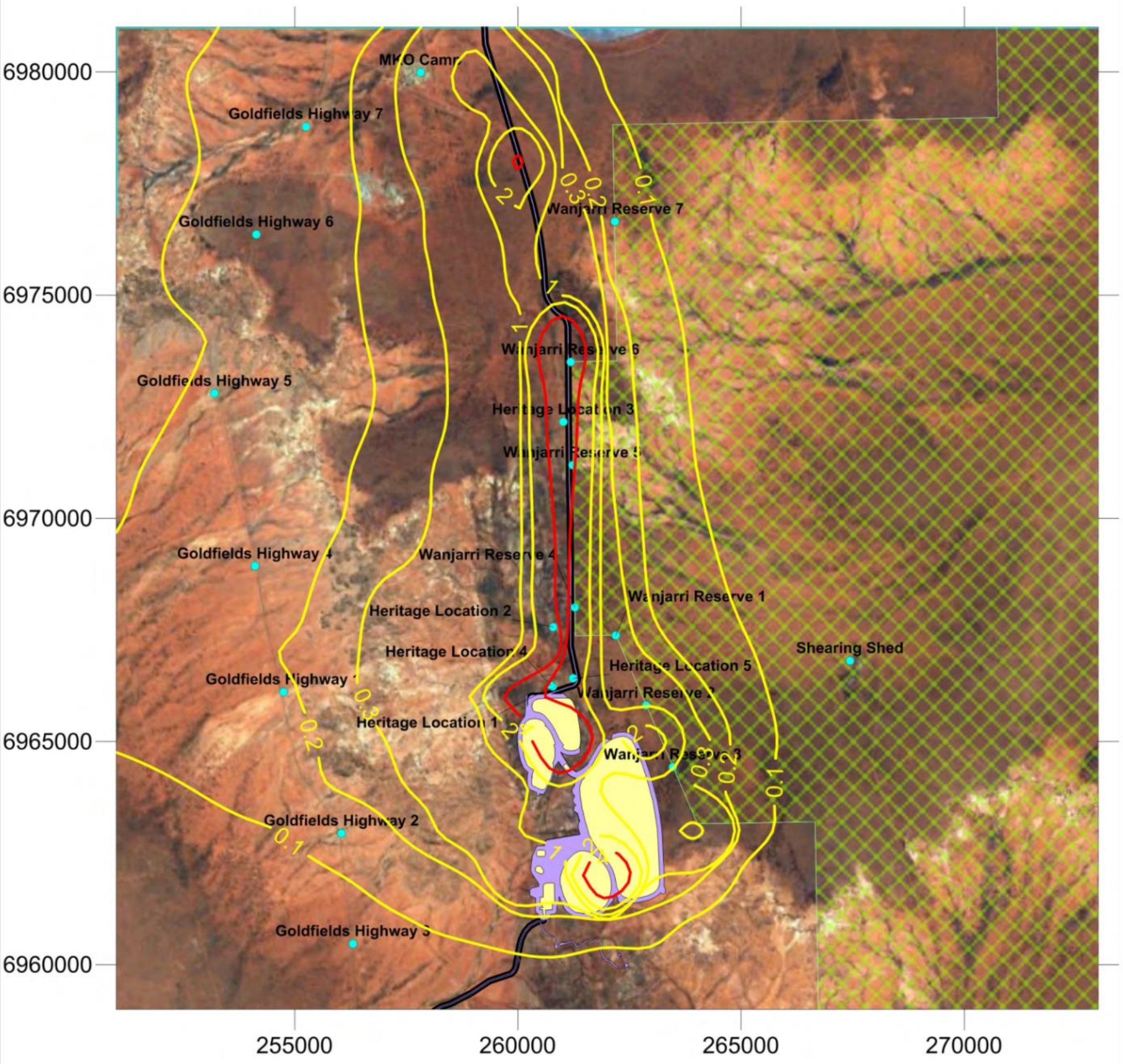


Figure 38 MKS Impacts to SRE Habitats in Development Envelope with Regional Context



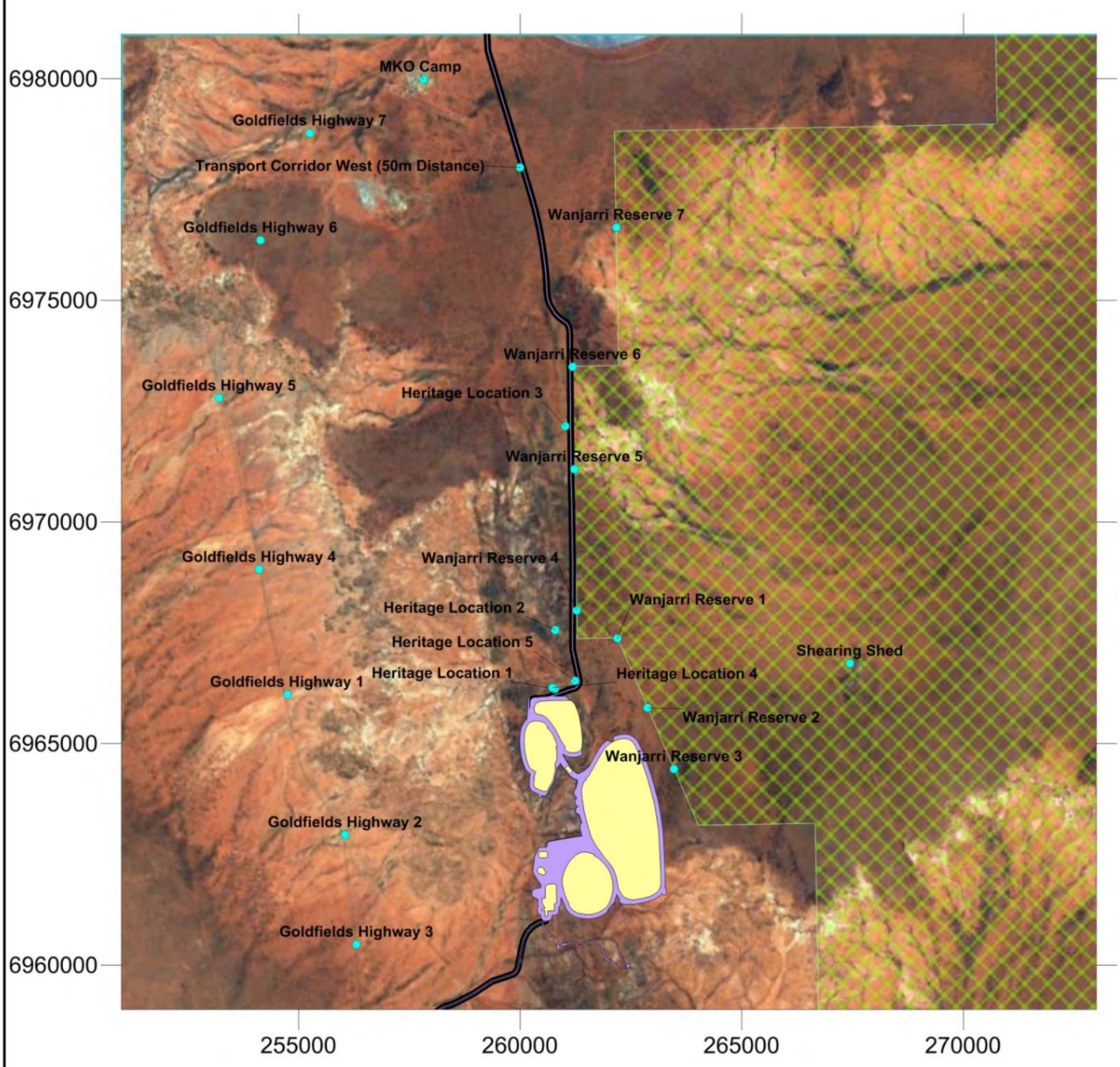
Scenario 1 – TSP Predicted Deposition (g/m^2/month)	Client: BHP Billiton Nickel West Pty Ltd		
	Project: MKSO Dust Modelling Assessment	Source: BHP Billiton	Date: Mar 2017

Figure 39 Predicted dust deposition TSP g/m2/month (Scenario 1: no dust control on haul road)



Scenario 2 – TSP Predicted Deposition (g/m^2/month)	Client: BHP Billiton Nickel West Pty Ltd	RAMBOLL ENVIRON	
	Project: MKSO Dust Modelling Assessment	Source: BHP Billiton	Date: Mar 2017

Figure 40 Dust deposition TSP g/m2/month (Scenario 2: watering <2 l/m^2/hour haul road)



Discrete Receptor Locations	Client: BHP Billiton Nickel West Pty Ltd	RAMBOLL ENVIRON	
	Project: MKSO Dust Modelling Assessment	Source: BHP Billiton	Date: Mar 2017

Figure 41 Dust deposition TSP g/m2/month (Scenario 3: watering >2 l/m2/hour haul road)

6.5 Mitigation, Residual Impacts and Outcomes

A summary of the key mitigation measures to address potential impacts on fauna are listed in Table 34. This includes consideration of mitigation strategies required to manage inherent impacts and residual impacts after the application of these measures. The Significant Residual Impact Model as detailed in the WA Environmental Offsets Guidelines (2014) has been applied to the Proposal, as detailed in Table 67.

Table 34 Environmental management of Fauna

EPA Objective	**To protect terrestrial fauna so that biological diversity and ecological integrity are maintained**	**Outcomes**
Inherent Impacts Requiring Management	**Mitigation Strategies**	
Clearing of native vegetation resulting in loss and/or fragmentation of faunal (terrestrial and SRE invertebrate) habitat; altered fire regime and associated change and/or loss of vegetation. Loss of creekline habitat in Jones Creek due to construction of two creek crossing. Mining activities resulting in increased spread of weeds. Light, noise and vibration resulting in changes in faunal behaviour and community structure. Dust from mining activities resulting in reduced vegetation health and condition. Increase in sediment load to Jones Creek resulting in sedimentation downstream.	**Avoid** • Disturbance footprint designed to reduce disturbance to fauna habitats. • Vegetation clearing to be limited to 878ha, with no clearing or mining activities to occur within Wanjarri Nature Reserve. • Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to Sherwood Breakaways habitat and Areas of Internal Drainage - Mulga habitat. **Minimise** • Land disturbance, including within Jones Creek for creek crossing construction, kept to a minimum of what is necessary for development of the Proposal within the design footprint. • Existing internal ground disturbance procedures and permitting system will be implemented ("Environmental and Heritage Impact Approval" process). • Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. • Dust suppression, including use of water carts on access roads, to be implemented during all Proposal phases. • Lighting designed to illuminate designated operations areas rather than the surrounding landscape. • Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to the Proposal via transport route. • Implement biannual weed monitoring and targeted spraying program at the Proposal following completion of land clearing activities and during operations and closure activities. • Firefighting equipment will be located on site and emergency personnel will be trained in fire response. • A Hot Work Permit system will be implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Proposal site induction to include information on prevention and management of fires. • Putrescible wastes associated with site offices to be stored in bins with lids and transferred to Mt Keith operations for disposal. • No feeding of native animals. • Designated speed limits on access and haul roads to reduce fauna strikes. • Removal of dead fauna away from edges of roads. • Mitigation actions for creek crossings within Jones Creek discussed in Section 11. **Rehabilitate** • Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	**Residual Impact** The following residual impacts are considered to be of minor significance at both local and regional scale. Clearing will necessitate the removal of some vertebrate and SRE invertebrate faunal habitat. Minor disturbance (1.4%) to Eucalyptus dominated ephemeral drainage line habitat within Jones Creek will occur in the formation of two creek crossings. Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. No direct impacts on the Wanjarri Nature Reserve will occur. While the vegetation of the Study Area plays a role in providing fauna habitat, none of the Vegetation Associations that are impacted in development of the Proposal are known to provide habitat critical to the maintenance of fauna species. The proposed development has been designed to minimise impacts to the eucalypt dominated ephemeral drainage line of Jones Creek, which is considered to be the most significant of habitats from a short-range endemic fauna utilisation and refuge perspective. The impact on the riparian vegetation is restricted to creek crossings, with remaining riparian vegetation undisturbed. The residual impact to riparian vegetation is considered to be minor. The remaining available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of conservation significant vertebrate and SRE invertebrate species. NiW considers that the Proposal meets the objective for this factor. **Offsets** Based on the expectation that the clearing will not have significant residual impacts, no offsets are proposed.

7 Subterranean Fauna

7.1 EPA objective, policies and guidelines

The EPA's objective for subterranean fauna is:

> "to protect subterranean fauna so that biological diversity and ecological integrity are maintained;"

where ecological integrity is the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements.

Subterranean fauna is defined by the EPA, for the purposes of EIA, as fauna that live their entire lives (obligate) below the surface of the earth. They are divided into two groups:

- stygofauna – aquatic and living in groundwater; and
- troglofauna – air-breathing and living in caves and voids.

The policy and guidance documents considered in the environmental impact assessment for this factor are listed in Table 35. The ERD is consistent with these documents.

Table 35 Policy and guidance relevant to Subterranean Fauna

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Subterranean Fauna (EPA, 2016).	Outlines how the EPA considers subterranean fauna in the EIA process, including how this factor links with other environmental factors.	The ERD describes the subterranean fauna habitat and species occurring within the Study Area. A number of subterranean fauna surveys have been undertaken in the area surrounding the Proposal (≤200 km), predominantly within calcrete associated groundwaters. The assessments found that troglofauna do not represent a key environmental factor, and the focus of this assessment has therefore been on stygofauna species and habitat. No conservation significant species, threatened or priority ecological communities have been identified within the Study Area or surrounding area. The nearest community is located approximately 16km to the south of the proposed pit outlines. The direct impacts to stygofauna are the removal of subterranean habitat through mining excavation of the Goliath and Six Mile pits, and drying out of habitat through lowered groundwater table associated with pit dewatering. The ERD demonstrates that the development of the pits and the wider Proposal, will not propose a long term conservation risk at local and regional scale. NiW considers that the EPA's objective for subterranean fauna can be met.
Other Policy and Guidelines		
Technical Guidance – Sampling Methods for Subterranean Fauna (EPA, 2016).	Provides guidance on the EPA's position in relation to what are acceptable sampling efforts and methodologies for subterranean fauna. This draft document currently retains the format and content of EPA	The subterranean fauna assessment for the Proposal (Appendix L) was designed in accordance with EPA 2016 sampling and survey guidance documents.

Policy and Guidelines	Key Aspects	Application
	Guidance Statement No 54A Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA, 2007). It was designed to serve as a technical appendix to Guidance Statement 54 (EPA, 2003), which has now been superseded by *Technical Guidance – Subterranean Fauna Survey* (EPA, 2016).	
Technical Guidance – Subterranean Fauna Survey (EPA, 2016).	Provides guidance on the relevant impact assessment methods where subterranean fauna is likely to be a factor, particularly the standards of survey and type of information required to understand impacts. It differs from previous guidance by introducing the use of surrogates, where survey alone has not provided sufficient evidence to determine distribution. It requires specimens to be submitted to the WA Museum to enable knowledge sharing and to improve understanding of subterranean fauna. This document currently retains the format and content of *EPA Environmental Assessment Guideline No 12. Consideration of Subterranean Fauna in Environmental Impact Assessment in WA* (EPA, 2013) that superseded *Guidance Statement 54 Consideration of subterranean fauna in groundwater and caves during environmental impact assessment in WA* (EPA 2003).	
WA Environmental Offsets Policy (Government of Western Australia, 2011)	The Western Australian Government's Environmental Offsets Policy seeks to protect and conserve environmental and biodiversity values for present and future generations. The overarching objective of policy is to ensure that economic and social development may occur while supporting long term environmental and conservation values. The policy seeks to ensure that environmental offsets are applied in specified circumstances in a transparent manner to engender certainty and predictability, while acknowledging that there are some environmental values that are not readily replaceable. It serves as an overarching framework to underpin environmental offset assessment and decision-making in Western Australia.	The subterranean fauna values within the MKS Study Area were assessed following the Offsets Guidelines (2014). Under the residual impact significance model no offsets are considered to be required as the MKS proposal was found not to represent a significant residual impact to the subterranean fauna values present.
WA Environmental Offsets Guidelines (Government of Western Australia, 2014)	These guidelines complement the WA Environmental Offsets Policy 2011 (offsets policy) by clarifying the determination and application of environmental offsets in Western Australia. Application of these guidelines will ensure that decisions made on environmental offsets are consistent and accountable under the Environmental Protection Act 1986 (the EP Act).	

Policy and Guidelines	Key Aspects	Application
	These guidelines apply to all biodiversity offsets required as a condition of Western Australian environmental approval processes. An EPA assessment report will set out the EPA's recommendation as to whether or not the proposal should be implemented and, if so, any conditions and procedures it should be subject to. These recommended conditions may include offsets if a significant residual impact remains after mitigation.	

7.2 Receiving environment

Study Area and Survey Effort

A summary of subterranean fauna studies undertaken within the region surrounding the Project Area is shown in Table 36, Figure 42 to
Figure 44. NiW commissioned Stantec Australia (previously MWH Australia) to undertake further surveys for the Proposal, in 2016 and 2017. The survey results are provided in Appendices L (MWH, 2016b) and M (Stantec, 2017b), respectively.

Troglofauna

As part of MWH (2016b) survey, troglofauna were sampled in accordance with EPA Guidance Statement No 54a (current at the time). The troglofauna survey involved 67 litter trap samples deployed over two trapping rounds conducted for nine weeks during March to May, 2011, and for seven weeks during May to July, 2011. In addition, 14 net haul scrape samples were also collected.

The Study Area was found to host a troglofauna assemblage of very low species richness and abundance. No troglofauna were recorded from within the Development Envelope. Two species were collected within the Study Area: *Troglarmadillo* sp. OES3 (known from two specimens only) and Campodeidae sp. OES2 (known from one specimen).

An assessment of survey adequacy found that no further troglofauna sampling is required to more reliably characterise the assemblage present. The proposed Project is considered not to pose a risk to the long-term survival of any known troglofauna species as no species were collected from the within the proposed impact areas. In addition, the distributions of potentially undetected troglomorphic species are unlikely to be restricted to small areas such as the proposed impact areas because of the continuity and extent of habitat present (MWH, 2016b).

Stygofauna

Stygofauna samples were taken from exploration drill holes and bores constructed specifically for stygofauna sampling using haul nets, which have been found to be the most efficient collection method (Allford *et al.*, 2008). Sampling and reporting was undertaken in accordance with current EPA guidance listed in Table 35, and the method described in Stantec (2017b) (Appendix M). A total of 221 stygofauna net haul samples were collected from 61 bores over eight sample rounds. The first sample round was undertaken in 2006 with five samples collected by Biota (2006a). The additional seven sample rounds were undertaken by Stantec (as Outback Ecology and MWH): November 2010; March and June, 2011; February 2012; March, May and August, 2017 (Table 36).

The surveys have described the stygofauna habitats and fauna assemblages of the Development Envelope and the surrounding areas (Appendix M). The locations of the sampling bores are shown in

Figure 43 and

Figure 44.

Table 36 and Figures 42 to 45 provide a summary of the stygofauna survey effort and sampling locations.

Table 36 Subterranean fauna surveys undertaken within the region surrounding the Study Area (Stantec, 2017b)

Area / Deposit	Distance from Proposal	Subterranean Fauna	Geology/Habitat	Reference
TROGLOFAUNA SURVEYS				
Yakabindie	Within Proposal area	Isopods	Regolith, fractured rock	MWH, 2016b
Lake Miranda (East and West)	25km south	Isopods	Calcrete	Javidakar 2014, WA Museum 2016b
Yakabindie Station	25km south	Psuedoscorpions, symphylans	Specific geology unknown	WA Museum 2016a
Lake Maitland/ Barwidgee	55km north-east	Chilopods, hemipterans, isopods, pauropods, psuedoscorpions	Calcrete, alluvium, colluvium	Outback Ecology 2012b
Lake Way (Hinkler Well) Lake Way (Lake Violet) Lake Way (Uramurdah)	75km north-east 90km north-west 90km north-east	Diplurans, pauropods, pseudoscorpions, isopods, polyxenid millipedes, silverfish, spiders, symphylans	Calcrete, alluvium	Platnick 2008, MWH 2015, WA Museum 2016a
Millbillillie Bubble Well	110km north-west	Pseudoscorpions	Specific geology unknown – likely calcrete	WA Museum 2016a
Depot Spring	70km south-west	Spiders	Specific geology unknown	WA Museum 2016a
Yeelirrie	85km north-west	Diplurans, hempterans, ispods, myriapods, palpigrades, pseudoscorpions, spiders, silverfish	Calcrete	Subterranean Ecology 2011, Bennelongia 2015b
Sturt Meadows	140km south	Palpigrades, pdeudoscoprions	Calcrete	Barranco and Harvey 2008, Edward and Harvey 2008
STYGOFAUNA SURVEYS				
Yakabindie	Within Proposal area	Amphipods, digochaetes, syncarids	Regolith, fractured rock aquifers	Biota 2006a, MWH 2016b
Cliffs	22km north	No stygofauna present	Weathered bedrock	Sinclair Knight Merz 20014
Lake Miranda (East and West)	25km south	Dytiscid beetles	Calcrete	Watt and Humphreys 2006
Albion Downs	30 km north	Amphipods, copepods, mites	Calcrete	Biota 2006a
Lake Maitland/ Barwidgee	55 km north-east	Amphipods, copepods, isopods, oligochaetes, ostracods, syncarids	Surficial aquifers, often calcrete	Golder Associates 2010, Cooper *et al.* 2007, Outback Ecology 2012a
Lake Way South	60 km north	Amphipods, copepods, oligochaetes, syncarids	Alluvium and dune deposits	Biota 2006a, Outback Ecology unpublished data
Lake Darlot	65 km south-east	Copepods	Specific geology unknown	Western Australian Museum 2016b
Depot Springs	75 km south-west	Amphipods, syncarids, copepods	Colluvium and calcrete	Environmental Protection Authority 2001, Cooper *et al.* 2007
Lake Way (Hinkler Well) Lake Way (Lake Violet) Lake Way (Uramurdah) Lake Way (Millbillilllie)	75 km north-west 90 km north-west 90 km north-east 135 km north	Amphipods, dytiscid beetles, copepods, isopods, oligochaetes, syncarids	Calcrete	Taiti and Humphreys 2001, Karanovic 2004, Cho *et al.* 2006, Cooper *et al.* 2007, Cooper *et al.* 2008, Watts and Humphreys 2009, Cho and Humphreys 2010, Outback Ecology 2012c, MWH 2015
Yeelirrie	85 km north-west	Amphipods, annelids, copepods, dytiscid beetles, isopods, ostracods, syncarids	Calcrete	Subterranean Ecology 2011, Bennelongia 2015
Jaguar	110 km south	No stygofauna recorded during preliminary investigations	Specific geology unknown	Department of Mines and Petroleum 2010

Area / Deposit	Distance from Proposal	Subterranean Fauna	Geology/Habitat	Reference
Marshall Creek Borefield	110 km south	Copepods	Silcrete and alluvial sand	Environmental Protection Authority 2001
Sandstone South Borefield	125 km south-west	Copepods	Highest numbers - calcrete/silcrete	
Sturt Meadows	140 km south	Amphipods, copepods, dytiscid beetles, oligochaetes	Calcrete	Environmental Protection Authority 2001, Bradford *et al.* 2010, King *et al.* 2012
Paroo Station	160 km north	Amphipods, aphanoneurans, dytiscid beetles, copepods, isopods, oligochaetes, ostracods, rotifers, syncarids	Calcrete, chert	De Laurentiis *et al.* 2001, Cho *et al.* 2006, Cooper *et al.* 2007, Watts and Humphreys 2009, Biota 2006b, Outback Ecology 2008, 2010, Bennelongia 2013

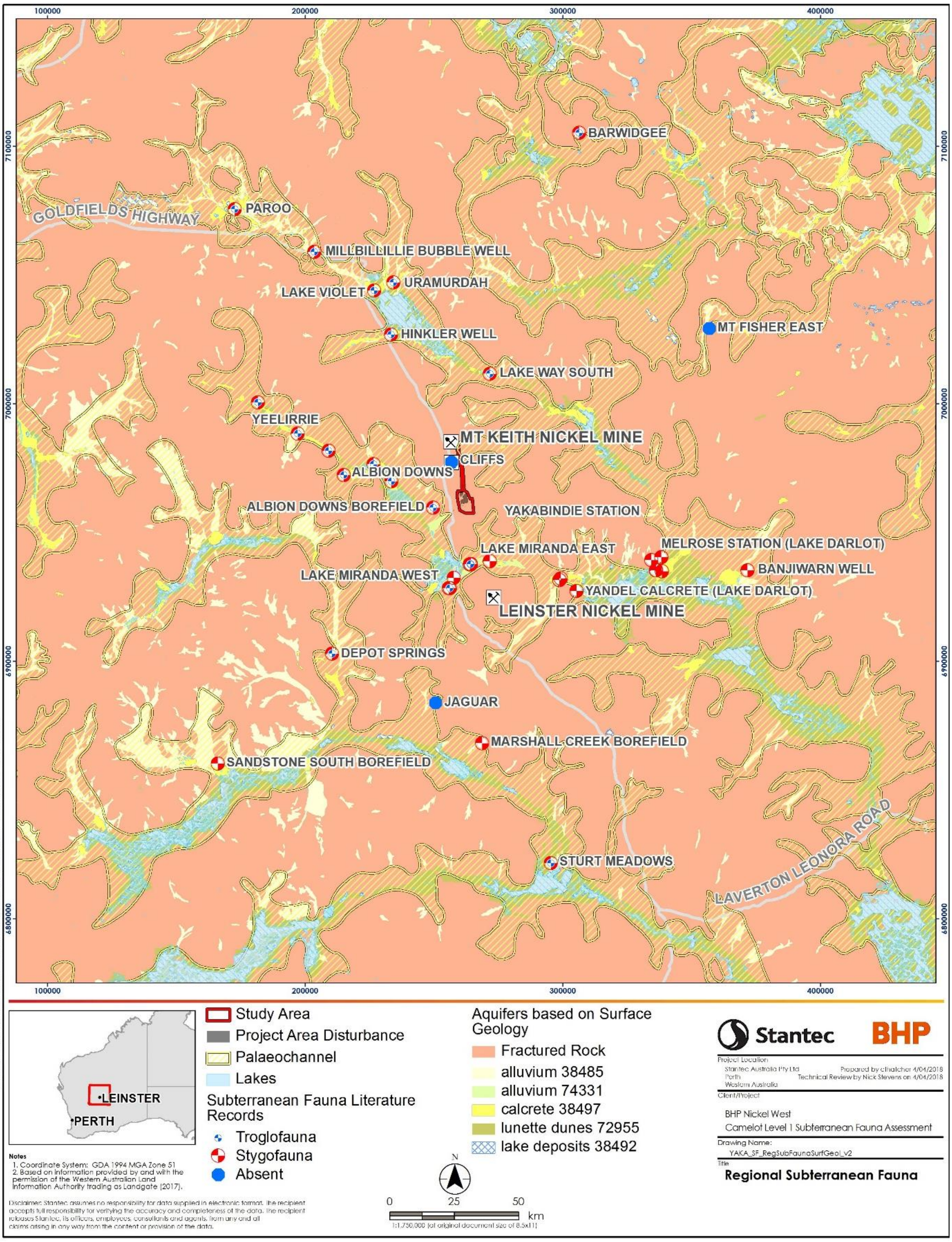


Figure 42 Subterranean fauna records from literature and database searches for the region surrounding the study area relevant to paleodrainage channels and calcrete systems.

Table 37 Summary of Stygofauna survey effort

<table>
<tr><th colspan="3" rowspan="2">Area</th><th colspan="3">No. Samples</th><th rowspan="2">No. Bores</th></tr>
<tr><th>2006-2012</th><th>2017</th><th>Total</th></tr>
<tr><td rowspan="3">Impact</td><td rowspan="2">Inside Proposed Pit Boundaries</td><td>Goliath</td><td>12</td><td>9</td><td>21</td><td>6</td></tr>
<tr><td>Six Mile Well</td><td>4</td><td>18</td><td>22</td><td>7</td></tr>
<tr><td>Within Modelled 0.5 mbSWL Groundwater Drawdown</td><td>Six Mile Well</td><td>4</td><td>60</td><td>64</td><td>20</td></tr>
<tr><td colspan="2" rowspan="3">Non-Impact</td><td><500m</td><td>4</td><td>12</td><td>16</td><td>4</td></tr>
<tr><td>>500m, <1km</td><td>22</td><td>23</td><td>45</td><td>12</td></tr>
<tr><td>>1km</td><td>18</td><td>35</td><td>53</td><td>12</td></tr>
<tr><td colspan="3">Totals</td><td>64</td><td>157</td><td>221</td><td>61</td></tr>
</table>

There were a total of 107 impact stygofauna samples collected with 43 samples from within the proposed mine pit boundaries of Goliath (21) and Six Mile Well (22), and 64 samples from within the modelled 0.5 mbSWL groundwater drawdown contour associated with dewatering of the Six Mile Well pit (Table 37). There were 114 non-impact stygofauna samples collected. Sixteen non-impact samples were collected from two bores (GOL12 and GOL13) that are within 200 m of the proposed Goliath pit boundary. However, both bores are not considered to be within the groundwater drawdown zone associated with the mining of the Goliath pit because the Goliath deposit is considered to be associated with an isolated and limited surficial regolith aquifer system (MWES Consulting 2017b). Groundwater drawdown will be highly confined and would not extend an appreciable distance beyond the proposed Goliath pit boundary due to the absence of permeability within and surrounding the deposit. Therefore, the need for modelling groundwater drawdown was considered unnecessary (MWES Consulting 2017b). The limited regolith groundwater resource will be completely removed with the development of the Goliath pit (Stantec, 2017b).

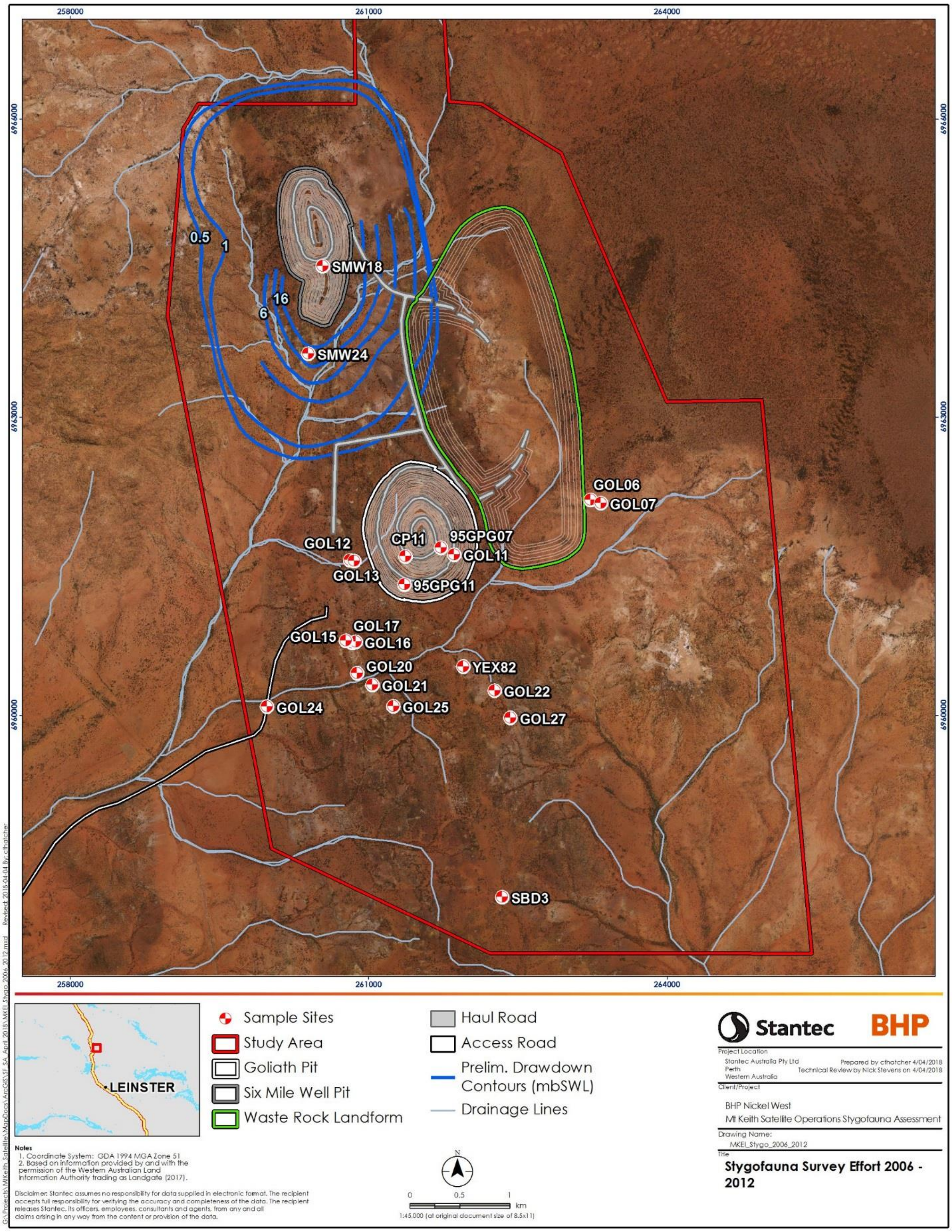


Figure 43 Stygofauna 2006 to 2012 survey bore locations in relation to proposed Proposal footprint

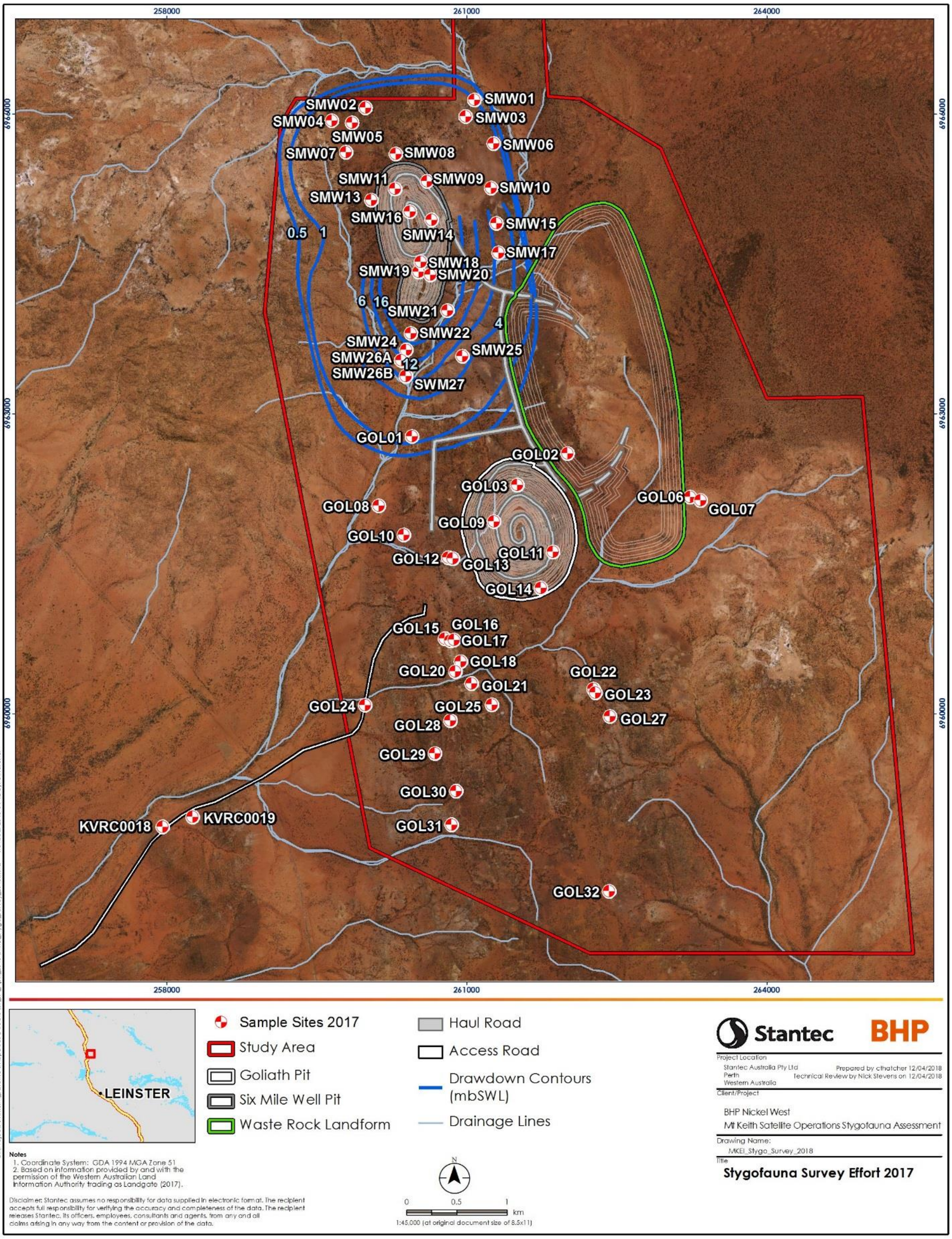


Figure 44 Stygofauna 2017 survey bore locations in relation to the Proposal

Stygofauna Habitat

The prospective habitat for subterranean fauna (stygofauna and troglofauna) is dependent on the presence of voids of suitable size and connectivity to satisfy biological requirements. Subterranean fauna were previously believed to be mostly restricted to karst landscapes that provide a relatively high degree of secondary porosity, but in more recent times have been found to occur in various types of non-karstic geologies and aquifer systems that exhibit suitable voids for colonisation (Humphreys 2008). Stygofauna are known to occur in non-karstic aquifers in course alluvial sediments, fractured rock, pisolites and thin rocky regoliths (Halse *et al.* 2014, Humphreys 2006, 2008, MWH 2016b, Outback Ecology 2014). The extent of stygofauna habitat is dependent on the interconnection of sub-surface crevices, fractures and voids, within suitable hydrogeological units and aquifer systems. In addition to allowing for the movement of stygofauna, adequate interconnected void spaces and associated high permeability can provide pathways for infiltration (vertical or lateral) of resources such as oxygen and carbon, key factors influencing stygofauna persistence and distribution (Humphreys 2008, Strayer 1994). Geological and hydrogeological studies can give an indication of the extent of stygofauna habitat present by providing information on the geological units and structures present, as well as groundwater flow or yield characteristics (aquifer parameters) (Stantec, 2017b).

The geology of the Study Area is described in Section 5, and is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite, which host the nickel sulphide deposits (MWES Consulting 2017b).

The Proposal is located within the upper catchment of the Jones Creek which is a lateral tributary system, incised into the Barr-Smith Range. The majority of runoff for this ephemeral water course is received from the upper catchment, which covers an area of 64.1 km2. In large flood events, water is rapidly shed from this part of the catchment into the creek, aided by the rocky nature of the terrain. The terminus for the creek is a large floodplain area to the south west, containing a number of claypans (MWES Consulting 2017b). Beyond this, drainage becomes increasingly diffuse, before encountering the Yakabindie calcrete and reaching Lake Miranda, located within the Carey Palaeodrainage system (Wetland Research and Management 2005) (Stantec, 2017b).

This catchment lies within the larger catchment of an ancient river system, the Carey Palaeodrainage, which once flowed south east into the Eucla Basin. Major fresh and hypersaline aquifers are contained within the palaeodrainage ground waters. Groundwater resources within the Carey Palaeodrainage catchment include calcrete, fractured rock and unconfined regolith (alluvial and colluvial) aquifers, a number of which are important in maintaining local stygofauna assemblages (Outback Ecology 2008, 2012a, b, d, Subterranean Ecology 2011a, Wetland Research and Management 2005). The greenstone landscape that dominates the Development Envelope is dissected by alluvial drainage lines (Stantec, 2017b).

Calcrete aquifer systems are recognized as providing optimal habitat for stygofauna in the Pilbara and Yilgarn, generally hosting more diverse and abundant assemblages than regolith or fractured rock associated aquifers (Allford *et al.* 2008, Environmental Protection Authority 2007, Humphreys 2008, Outback Ecology 2012d).

The Lake Miranda associated calcretes, Lake Miranda East, Lake Miranda West and Yakabindie, are the closest calcrete systems to the Proposal, located approximately 20 km to the south southwest, and near the terminus of the Jones Creek drainage system. Limited sampling of the Lake Miranda calcretes have collected a few stygofauna species (Watts and Humphreys 2006) and more intensive sampling may record richer assemblages from the system.

Few surveys in the region of the Proposal have sampled non-calcrete associated aquifer systems. Sampling of the weathered and fractured bedrock habitat at Cliffs, 22 km north of the Study Area, did not yield any stygofauna (Sinclair Knight and Merz 2004).

Within the current Study Area, regolith and fractured rock aquifers were sampled in 2006 (Biota 2006a). Sampling of five bores within the vicinity of the proposed Goliath pit area collected two amphipod (Neoniphargidae) specimens from GOL13 (previously known as YAKB06), approximately 200 m to the west of the proposed Goliath pit boundary, and a single oligochaete from GOL11 (previously known as

CP21) within the proposed Goliath pit (Biota 2006a). Recent sampling of a fractured rock and alluvial aquifer system located within the Raeside palaeodrainage channel, more than 170 km to the southeast of the Proposal, yielded a commonly collected but low species richness stygofauna assemblage dominated by bathynellacean taxa (Stantec, unpublished data). The distribution of stygofauna found occur mostly along the main drainage lines as well as along known fault lines and shear zones (Stantec, 2017b).

Within the surrounding northern Goldfields region, genetic studies have indicated that calcrete systems can represent closed ‘subterranean islands’, in that the species of the stygofauna assemblage present are restricted in distribution to a particular calcrete (Cooper *et al.* 2002, Cooper *et al.* 2008, Guzik *et al.* 2008). The Lake Way calcrete systems have been shown to be unique in that genetic data has indicated that for some taxa gene flow does occur among the close neighbouring calcrete systems, particularly among the northern lake associated calcretes, Lake Violet and Uramurdah, and with Millbillillie Bubble Well calcrete. The genetic data was consistent with the hydrogeological assessment that surficial alluvial and regolith aquifers associated with the main drainage pathways provided hydraulic connections among the main calcrete aquifer systems (Stantec, 2017b).

There are times when the biological data can seemingly be at odds with the hydrogeological data. Genetic studies have demonstrated that hydraulic connections do exist between aquifers that hydrogeological data had indicated were largely separate systems. Genetic data did show that *Atopobathynella wattsi* has a distribution extending from the Lake Violet calcrete, on the northern shore of Lake Way, to the Hinkler Well calcrete, more than 12 km away on the western shore of Lake Way (Guzik *et al.* 2008). The Browns Range Metamorphics and Gardiner Sandstone fractured rock aquifer systems each exhibited distinctly different hydrogeological characteristics and were considered to be isolated from one another (Klohn Crippen Berger 2013). However, genetic analysis demonstrated that hydraulic connections did exist between the two fractured rock aquifer systems, with two bathynellicean species clearly shown to be distributed in both (Outback Ecology 2014, Stantec 2017b).

Aquifer characteristics

Groundwater in the Proposal Area and local region occurs in saprolite-weathered regolith, surficial alluvial and/or colluvial deposits, and within geological structures (faults, fractures, unconformities) forming shallow aquifers (<100 m deep) of variable size and uneven connectivity (MWES Consulting 2017b). Alluvial, Aeolian and/or colluvial deposits which form a surficial cover over the weathered greenstone terrain are only sporadically and partly saturated, as the depth to the water table in the Proposal Area is typically 25 m bgl or greater. Partial local saturation of these deposits is at least temporarily present along the major drainage lines, which periodically facilitate infiltration of water following high rainfall and surface runoff events (Wetland Research and Management 2005, Stantec 2017b).

The main aquifer found in the Proposal Area, the Six Mile Well semi-confined regolith “caprock” aquifer, occurs in the southern portion of the Six Mile Well Proposal Area only, based on the known bore lithologies and groundwater yields (MWES Consulting 2017b). Within the southern part of the proposed Six Mile Well pit area, the regolith aquifer appears confined to semi-confined with thick clay dominated strata overlying the saturated weathered ultramafic. To the south of the proposed pit boundary the regolith aquifer appears unconfined with the thickness of clay dominated strata decreasing considerably, ranging from absent to a maximum of 8 m thick. The saturated extent of the main regolith aquifer is considered to decline in parts to the south beyond the proposed pit boundary as the more deeply weathered ultramafics give way to less permeable fresh bedrock (BHP Billiton Nickel West 2011). However, the saturated depth of the heavily weathered zone is variable, extending to 38 m bgl (488 AHD) near to confluence of Jones Creek and one of its tributaries (MWES Consulting 2017b). This deeper weathering along the southeastern boundary of the Six Mile Well Proposal Area is likely a result of the fault lines and incised Jones Creek drainage channel present and would provide a connection to the alluvial and fractured rock aquifer systems associated with Jones Creek to the south (Stantec, 2017b).

The northern portion of the Six Mile Well Proposal Area (from SMW16 northwards) is not considered to host prospective stygofauna habitat as the saturated strata are either entirely fresh bedrock or heavily clay dominated, and therefore would not host the porosity or receive the influx of resources (e.g. nutrients, oxygen), due to the thick confining overlying clay layers, required for stygofauna habitation. The low groundwater yields indicate the low permeability and limited groundwater resource. The stygofauna habitat prospectivity to the east of the proposed Six Mile Well pit is similar to the northern portion of the Six Mile

Well Proposal Area with limited groundwater yields from the confined to semi-confined saturated clay dominated strata overlying mafic basalt saprock to freshrock (MWES Consulting 2017b) indicating limited porosity and resource influx (Stantec, 2017b).

Groundwater associated with the thin regolith of the Goliath deposit was not considered a substantial aquifer, with test pumping demonstrating low permeability in the area. Testing of the deeper, sub regolith aquitard, showed water yield was generally very low. The lithology of bores in and near the proposed Goliath pit indicate the lack of prospective habitat for stygofauna as the saturated strata are either entirely fresh bedrock or saprolitic clay dominated (Stantec, 2017b).

Groundwater also occurs, in smaller quantities, within fractured rock aquifers along geological structures in fresh fractured basement, fracture sets, and unconformities forming discrete aquifer units, with low storage and possibly limited connectivity (MWES Consulting 2017b). The permeability of the fractured rock zone can range from moderate to high but the porosity of the fault zones are relatively low and with limited lateral extent. From an ecological perspective, the spatial and temporal extent of connectivity via the 'interstitial highway' (Ward and Palmer 1994) among the regolith, alluvial and fractured rock aquifers associated with the upper Jones Creek catchment is likely to be dendritic in nature, relatively extensive and sufficient for gene flow to occur among potential stygofauna populations. The groundwater heads across the Proposal area, in the range of 504 to 510 AHD, are flat with a hydraulic gradient running south along Jones Creek and away from the deposit areas. The flat groundwater heads indicate that a reasonable degree of groundwater connectivity does exist across much of the Proposal Area (MWES Consulting 2017b), that is considered to be associated with the network of geological structures and regolith and alluvial aquifers present (Stantec, 2017b).

Groundwater properties

Groundwater properties, as represented by the basic suite of physiochemical parameter measures, indicate suitable conditions for stygofauna throughout the Study Area (Table 38).

Table 38 Groundwater properties of Study Area

Parameter	Study Area Properties
Salinity	Ranged from fresh to hyposaline, with highest salinities (> 10 000 uS/cm) typically recorded within pit or drawdown areas. Seasonal variation in salinity, with lower levels corresponding to recharge from winter rainfall, and higher concentrations in drier months of March to June. The salinity of the main regolith aquifer at Six Mile Well mostly ranged from 3,000 to 8,000 mg/L (Coffey Partners 1990) with surrounding isolated fractured rock aquifers generally of lower salinity ranging from 700 to 5,400 mg/L (Coffey Partners 1991).
pH	Ranged from circumneutral (6.5-7.5) to alkaline (>7.5). The most diverse stygal communities inhabit calcareous environments between pH 7.2 and 8.2 (Humphreys 2008), and while low pH can restrict distribution, some ostracods have been documented from pH as low as 4.4 (Reeves *et al.* 2007).
Dissolved oxygen	Ranged from 2.78 mg/L to > 7mg/L indicating oxygenated groundwater conditions present across the Study Area.
Temperature	Fluctuated with seasonal variations, ranging from 18.7 to 28.1°C.
Standing water level (SWL)	Variation reflected local topography across Proposal Area, particularly the Goliath region, with SWL closer to the surface to the south of Goliath at Serpentine Hill (15m bgl) with the area situated within a valley floor. The remaining bores were situated within regions of higher elevation, where the distance to groundwater was greater, averaging SWL's between 20 to 25m bgl. The standing water levels measured against the Australian Height Datum (AHD) were shown to be relatively flat across the Proposal Area (range: Six Mile Well deposit 502.9 to 505 m AHD; Goliath deposit 503.6 to 506.8 m AHD) with a slight hydraulic gradient running south down Jones Creek away from the deposit areas (499.2 m AHD).

Conservation significant species and communities

No Threatened Ecological Communities or PEC have been identified within the Study Area. The nearest priority subterranean communities occurred in conjunction with calcrete aquifers to the west and to the south of the Study Area. The Yakabindie calcrete community was the nearest, the associated buffer zone commencing approximately 16 km south of the proposed pit outlines. The Albion Downs calcrete community and Lake Miranda east and west calcrete communities were each located over 20 km away from the proposed pit outlines, to the west and south, respectively (Stantec, 2017b).

No threatened or priority subterranean fauna species have been identified within the Study Area or surrounds from DBCA database searches. A search of the Western Australian Museum (WAM) Crustacea database identified over 700 records of subterranean taxa in the region surrounding the Study Area (MWH 2016b). The closest records (within a radius of approximately 50 km) encompassed stygobitic taxa from groups including amphipods, copepods, isopods, ostracods and syncarids. The only WAM records from within the Study Area were the two *Atopobathynella* species, *A*. OES8 and *A*. OES9, and the ostracod *Gomphodella* sp. IK2 that had been collected as part of the subterranean fauna assessments (2006 to 2017 records, Appendix D of Stantec, 2107b). In general, the stygobitic crustaceans recorded in the region were predominantly associated with calcrete habitat in systems such as Yeelirrie, Lake Maitland/Barwidgee, Lake Miranda East and West calcretes and Albion Downs. The differences in the taxon diversity between geological units may be partly attributable to sampling bias. However, it is considered to also reflect the more favourable habitat within calcrete systems relative to regolith and fractured rock systems (Stantec, 2017b).

Fauna Assemblage

Ten taxa from four higher level taxonomic groups (Amphipoda, Bathynellacea, Oligochaeta, and Ostracoda) were collected in 12 of the 221 samples taken from eight of the 61 bores sampled. Only two bores (SMW18 and GOL20) recorded multiple species and yielded stygofauna specimens on more than one occasion. The remaining six bores only ever had one species recorded, and only on one occasion despite repeated sampling (Stantec, 2017b). The stygofauna survey results are provided in Appendix D of Stantec (2017 b) (Appendix M). Table 39 describes the Stygofauna diversity and distribution within the Study Area.

The findings for each of the proposed pit impact areas are summarised below:

<u>Goliath Pit</u>

No stygofauna taxa were collected from within the proposed Goliath pit boundary during the 2010 to 2017 stygofauna sample rounds. Previous sampling by Biota (2006a) did record indeterminate oligochaete material from bore GOL11, within the proposed pit boundary (

Figure 43). There is a high likelihood, due to the habitat characteristics present, the indeterminate material collected represents a semi-aquatic enchytraeid species that may be conspecific with other enchytraeid material recorded, and not represent a stygobitic phreodrilid species.

<u>Goliath Groundwater Drawdown</u>

No species are considered to have been recorded from within the Goliath groundwater drawdown impact zone. An amphipod, identified as a *Neoniphargidae*, was recorded in 2006 from bore GOL13 that is located approximately 200 m outside the proposed pit boundary

Figure 43).The extent of the groundwater drawdown that would be associated with the mining of the Goliath pit is not considered to extend far beyond the proposed pit boundary. Therefore, the recorded location of the Neoniphargid is considered to be outside of the groundwater drawdown impact zone associated with the dewatering of the Goliath pit.

<u>Six Mile Well Pit</u>

Three species, *Atopobathynella* sp. OES8, *A.* sp. OES11 and Enchytraeidae sp. OES23, were collected from within the proposed Six Mile Well pit boundary from SMW18 during the 2010 to 2012 stygofauna sample rounds (

Figure 43). No species were recorded from within the proposed pit boundary from the three sample rounds undertaken in 2017. However, in 2017 both *Atopobathynella* sp. OES8 and *A*. OES11 were recorded from outside of the proposed Six Mile Well pit boundary. *Atopobathynella* sp. OES8 was recorded in Goliath Proposal Area from GOL20, approximately 1 km from the proposed Goliath pit boundary and more than 4 km from SMW18 where the species was first recorded. *Atopobathynella* sp. OES11 was recorded from outside the proposed Six Mile Well pit from a newly drilled bore, SMW22, located within the modelled groundwater drawdown impact zone associated with pit dewatering. Enchytraeidae sp. OES23 is the only species to not have been recorded from outside the proposed pit.

<u>Six Mile Well Groundwater Drawdown</u>

Two species, *Atopobathynella* sp. OES11 and *Gomphodella* sp. IK2, were collected from within the modelled Six Mile Well groundwater drawdown (

Figure 43). *Atopobathynella* sp. OES11 was recorded in 2017 from the new bore SMW22, 150 m south of the pit boundary within the modelled groundwater drawdown impact zone. The Ostracoda species, Gomphodella sp. IK2, was collected on a single occasion in 2012 from bore SMW24, 340 m south of the pit boundary within the modelled 5 m bSWL groundwater drawdown impact zone. Both species are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The broader distribution of both species is supported by the wider distribution of Atopobathynella sp. OES8 and relatively high hapolotype diversity of *Atopobathynella* sp. OES11.

The Bathynellacea was represented by four species, *Atopobathynella* sp. OES8, *A*. sp. OES9, *A*. sp. OES11, and Bathynellidae sp. OES2. The Oligochaeta were represented by two semi-aquatic enchytraeid species, Enchytraeidae sp. OES10 and Enchytraeidae sp. OES23, and a stygobitic worm, Phreodrillidae sp. OES23. An indeterminate oligochaete specimen collected by Biota in 2006 could not be substantiated and taxonomically aligned with other oligochaete species recorded from the Study Area. However, the habitat from which it was collected indicates it is likely to be a semi-aquatic enchytraeid species. The Ostracoda was represented by a single species, *Gomphodella* sp. IK2, recorded from one sample only. The Amphipoda material was collected by Biota in 2006 and could not be located for further examination and so remains as an indeterminate taxa.

Atopobathynella sp. OES8 was found to be the most widespread species, with a range found to extend for over 4 km from the Six Mile Well pit area (SMW18) to the Goliath non-impact area (GOL20). *Atopobathynella* sp. OES11 was the only other stygofauna species to have been collected from more than one bore location; SMW18 inside the proposed Six Mile Well pit as well as SMW22 from outside the proposed pit boundary but within the modelled groundwater drawdown associated with Six Mile Well pit dewatering. Genetic analysis revealed *Atopobathynella* sp. OES11 to exhibit a relatively high CO1 haplotype diversity within a very limited geographical area, indicating the presence of a larger and more widespread population than shown by location records (Stantec, 2017b).

The remaining eight species were each recorded from singletons: Five species, *Atopobathynella* sp. OES9, Bathynellidae sp. OES2, Enchytraeidae sp. OES10, Neoniphargidae sp. A and Phreodrillidae sp. OES23, from single locations outside proposed impact areas; one species, *Gomphodella* sp. IK2 from within the Six Mile Well modelled groundwater drawdown zone; the two remaining taxa, the indeterminate Oligochaeta and Enchytraeidae sp. OES23, have each only been recorded from inside the proposed pits, Goliath and Six Mile Well, respectively (Stantec, 2017b).

Table 39 Stygofauna diversity and distribution (Stantec 2017b).

Taxon	Abundance	Area	Bore ID	Location	Comments
Amphipoda					
indet. *Neoniphargidae* sp. (Biota 2006	2	Goliath	GOL13	Near pit (<200m)	Not of potential conservation concern. Indeterminate species collected by Biota (2006a). Specimen could not be found for further examination. No additional amphipod material collected or stygofauna recorded from bore in 2010 to 2017 sample rounds. Doubts do exist that an amphipod does occur in Study Area.
Bathynellacea					
Atopobathynella sp. OES8	1	Six Mile Well	SMW18	Inside & outside pits (>500m, <1km)	Not of conservation concern. DNA sequencing confirmed morphologically distinction from other *Atopobathynella* species. Most widespread species recorded from Study Area and recorded sympatrically with both *A*. OES9 and *A*. OES11.
Atopobathynella sp. OES11	39	Six Mile Well	SMW18, SMW22	Inside & near pit (150m) within groundwater drawdown	DNA analysis demonstrated that distinct from other *Atopobathynella* species. The relatively high haplotype diversity and intraspecific CO1 sequence divergence found suggest broader distribution than current location records show.
Oligochaeta					
Enchytraeidae sp. OES23	60	Six Mile Well	SMW18	Inside pit	Not considered to be of conservation concern. *Enchytraeidae* species generally considered widespread in distribution and not stygobitic, more likely to be semiaquatic stygoxenes. Are often collected in troglofauna litter traps.
indet. Oligochaeta sp. (Biota 2006a)	1	Goliath	GOL11	Inside pit	Indeterminate material collected by Biota (2006a). Specimen could not be found for further examination. Considered likely to be *Enchytraeidae* species due to the absence of suitable habitat for stygobitic fauna in recorded location, so unlikely to be *Phreodrilidae* species. Although this cannot be verified, record not considered to represent a species that would be of conservation concern.
Ostracoda					
Gomphodella sp. IK2	2	Six Mile Well	SMW24	Near pit (>300m, <500m)	Collected on a single occasion despite bore being sampled on seven occasions since 2010. Considered likely to have distribution extending beyond modelled groundwater drawdown, within upper Jones Creek catchment, based on broader distribution patterns exhibited by other stygobitic *Gomphodella* species in Yilgarn and Pilbara (Karanovic 2006, 2009).

Yellow shaded cells: taxa not recorded from beyond areas of likely groundwater drawdown

Orange shaded cells: taxa recorded from within the pit outlines only

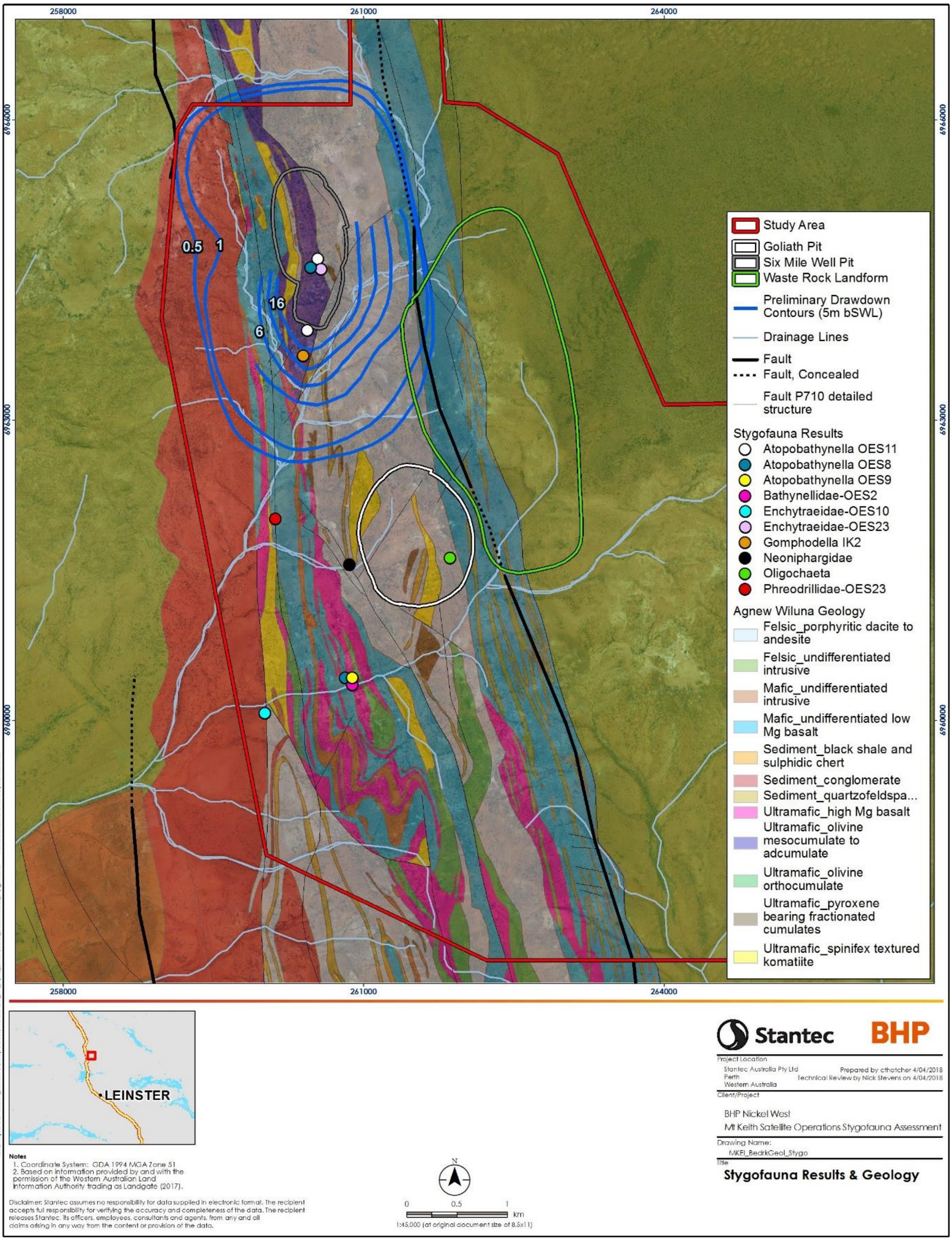


Figure 45 Distribution of recorded stygofauna taxa in relation to bedrock geology

Species Richness Estimates and Survey Adequacy

The species richness predicted to occur across the Study Area ranged from 11 to 16 species (Stantec 2017b). Five of the seven species richness estimators had reached a plateau or were trending downwards. The sampling completed was estimated to have recorded between 63 to 94 % of the assemblage predicted to exist. The extrapolation to a 100% increase in survey effort (441 samples) predicts that an additional two to three species would be collected.

The total number of stygofauna samples collected as part of this assessment (221; 94 impact) provides a reliable characterisation of the stygofauna values present in the Study Area and in relation to the proposed direct impact zones. Additional sampling is highly unlikely to further refine the knowledge of the stygofauna assemblage present when taking into consideration the low number of samples (12 of 221) and bores (8 of 61) that recorded stygofauna. The infrequent collection of stygofauna is further highlighted by the fact that from the repeated sampling of the eight bores that had recorded stygofauna, only two bores (GOL20 and SMW18) yielded stygobitic taxa on more than one occasion. Due to the sporadic and limited collection of stygofauna from bores with positive records, further targeted sampling was not considered warranted as would be unlikely to further elucidate stygofauna values within the Study Area (Stantec, 2017b).

Limitations of Subterranean Fauna Assessment

Specimens were identified to the lowest taxonomic level where possible. However, specimens could not always be identified to the level of species or morphospecies due to:

- loss or damage of important taxonomic features during collection and/or sorting of specimens;
- lack of adult specimens; or
- limitation in taxonomy, in that the current state of taxonomy for a particular group is insufficiently advanced, and/or relevant taxonomic keys and descriptions are lacking.

7.3 Potential impacts

The two main direct potential impacts on the stygofauna assemblage associated with the development of the Proposal are:

- removal of habitat through excavation of the proposed mining pits, Goliath and Six Mile Well; and
- drying out of habitat through the lowering of the groundwater table associated with mine pit dewatering.

7.4 Assessment of impacts

Both pit excavation and lower groundwater levels pose varying degrees of risk to the conservation of four of the ten stygofauna species that were only recorded from within the proposed mining areas and/or modelled groundwater drawdown zones.

The low diversity and sporadic occurrence (both spatially and temporally) of stygofauna collected from the Study Area correlates with the overall hydrogeological assessment that the regolith, alluvial and fractured rock aquifers present are minor and relatively hydraulically isolated, with many portions of the Proposal Area lacking suitable habitat to support stygofauna. The northern, western and eastern portions of the Six Mile Well Proposal Area, and the Goliath deposit area and southern Goliath reference areas, were confirmed to not host prospective stygofauna habitat as the saturated strata are entirely fresh bedrock and/or heavily clay dominated with no stygobitic species collected despite repeated sample rounds since 2010 (Stantec, 2017b).

The southern portion of the Six Mile Well Proposal Area, between the confluence area of the upper Jones Creek and one of its tributaries, was confirmed to host prospective stygofauna habitat within the unconfined portion of the regolith aquifer present, where no thick confining/semi-confining clay dominated strata existed. Stygobitic taxa were recorded from three bores (SMW18, SMW22 and SMW24) that intercepted the unconfined weathered ultramafic and fractured bedrock near to incised drainage channels. Outside of the Six Mile Well Proposal area only two bores (GOL08 and GOL20) each located near to drainage lines have confirmed records of stygobitic taxa. Both bores do not intercept weathered ultramafic regolith aquifers demonstrating that stygofauna habitat is not confined to regolith aquifers in the Proposal Area such as those that occur within each of the deposit areas (Stantec, 2017b).

The irregular and patchy nature of the stygofauna habitat present is evident to a high degree in the Study Area. The stygofauna inhabited areas appear to be along narrow pathways in the form of a dendritic network across the Study Area. The inhabited network does appear to mimic the main drainage channels with most of the bores recording stygofauna located near incised water courses. Such locations would likely receive higher surface water infiltration rates (i.e. resource influx) and greater degree of weathering of geological units and structures present leading to higher level of secondary porosity (i.e. habitable space) (Stantec, 2017b).

The distributions and genetic diversity exhibited by *Atopobathynella* sp. OES8 and *Atopobathynella* sp. OES11 do support the hydrogeological information that the habitable portion of the Six Mile Well regolith aquifer system is hydraulically connected to a network of other regolith and fractured rock aquifers associated with the upper Jones Creek catchment. The distribution of *Atopobathynella* sp. OES8 demonstrates that the hydraulic network extends at least to the non-impact zones within the Goliath Proposal Area. However, the possibility does exist that the network extends further south along Jones Creek and associated main tributaries. Most of the bores sampled since 2010 that had confirmed positive stygofauna records were set in or adjacent to ephemeral drainage channels that form the very upper extent of the headwaters of the Jones Creek catchment area. Therefore, the habitat sampled may likely to represent the outer distribution limits or periphery of the stygofauna assemblage within the middle to upper Jones Creek catchment (Stantec, 2017).

The stygofauna results have revealed the stygofauna assemblage to be sparsely distributed and infrequently collected. The low stygofauna abundance and sporadic occurrence (both spatially and temporally) does make it difficult to reliably assess the potential risks posed by the development of the Proposal to the stygofauna assemblage recorded. However, the biological and hydrogeological evidence available does indicate that the distribution patterns of the stygofauna recorded are dendritic-like, reflecting the habitable groundwater networks closely associated with the main drainage channels, and therefore considered to extend beyond each of their recorded locations as shown by *Atopobathynella* sp. OES8 whose range extends for over 4 km from the Six Mile Well pit area to the Goliath non-impact area. Of the ten stygofauna taxa recorded from the Study Area, four species of the assemblage have each only been recorded from within proposed pit boundaries and/or modelled groundwater drawdown impact zones (Stantec, 2017b).

The development of the Goliath deposit is not considered to pose a long term conservation risk to any stygofauna species, in particular the indeterminate Oligochaeta species, due to the lack of prospective stygofauna habitat present and the likelihood that the Oligochaeta species is a semi–aquatic enchytraeid and not stygobitic, and therefore would have a broader distribution, as demonstrated by many other enchytraeid species from other impact assessments, that would extend beyond the Goliath impact zone.

The development of the Six Mile Well deposit will impact populations of three species, Enchytraeidae sp. OES23, *Atopobathynella* sp. OES11 and *Gomphodella* sp. IK2, that were not recorded from outside the proposed impact areas. Enchytraeidae sp. OES23, has only been collected from within the proposed Six Mile Well pit boundary. However, this species is not considered to be stygobitic and likely to possess a broader distribution as has been shown for many other enchytraeid species from the Yilgarn. *Atopobathynella* sp. OES11 has been recorded from inside the proposed Six Mile Well pit as well as from the southern portion of the Six Mile Well Proposal Area that occurs outside the pit boundary but within the modelled groundwater drawdown. The CO1 haplotype diversity for *Atopobathynella* sp. OES11 indicates the presence of a relatively large and more widespread population than location records may show. Records of other *Atopobathynella* species from fractured rock aquifer systems have demonstrated that species distributions within catchment areas often range for greater than five kilometres, with a linear distance of over 15 km recorded (Outback Ecology 2014, Stantec, unpublished data). *Gomphodella* sp. IK2 has been recorded from outside the proposed Six Mile Well pit in the southern portion of the Six Mile Well Proposal Area, within the groundwater drawdown that is modelled to exceed 5 mbSWL and remove most of the saturated habitat in the immediate vicinity. *Gomphodella* sp. IK2 has only been recorded from a single sample from bore SMW24 in 2012, despite repeated sampling (7 samples) of the site since 2010. Records of other stygobitic *Gomphodella* species from calcrete and associated alluvial aquifer systems in the Yilgarn and Pilbara (e.g. *Gomphodella glomerosa* and *Gomphodella hirsuta*, respectively) have demonstrated relatively widespread distributions that exceed 5 km (Karanovic 2006, 2009). All three species are considered to be more broadly distributed and occur outside the impacted habitable portion of the Six Mile Well regolith aquifer system, when taking into account physical and biological information available.

The physical data available from the southern portion of the Six Mile Well Proposal area shows deeper weathering is present along the southeastern boundary of the Six Mile Well Proposal Area, likely a result of the fault lines and incised Jones Creek drainage channel present, which is considered to have hydraulic connection to the alluvial and fractured rock aquifer systems associated with Jones Creek to the south. Evidence for this is the relatively flat static groundwater levels exhibited that indicate a degree of groundwater connectivity does occur across much of the Study Area. This is further supported by the broader distribution of *Atopobathynella* sp. OES8 that demonstrates that hydraulic connections do exist between the Six Mile Well and Goliath Proposal Areas.

The remaining six species recorded from the assemblage in the Study Area are not at risk from the impacts of the proposed Proposal as they have all been found to occur in non-impact zones.

7.5 Mitigation, Residual Impacts and Outcomes

A summary of a review of key mitigation measures to address potential impacts on subterranean fauna are listed in Table 40. This includes consideration of potential mitigation strategies to manage proposed impacts and residual impacts. Under the residual impact significance model the proposed areas of impact associated with the development of Goliath and Six Mile Well pits are not recognised as hosting high biological values or representative of high biodiversity. The proposed development of the MKS Project is not considered to represent a significant residual impact to the subterranean fauna assemblage recorded within the Study Area and therefore, no offsets are considered to be required.

Table 40 Environmental Management of Subterranean Fauna

EPA Objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained	
Proposed Impacts	**Mitigation Strategies**	**Outcomes**
Direct Impacts: Removal of habitat through excavation of the proposed mining pits, Goliath and Six Mile Well; and Drying out of habitat through the lowering of the groundwater table associated with mine pit dewatering.	**Avoid & Minimise** Avoidance and minimisation measures to mitigate the impacts of mining excavation and associated groundwater drawdown on components of the subterranean fauna assemblage recorded are limited. Proposed mining areas are well defined that will insure only target areas will be disturbed, thereby limiting impact area to proposed limits. Goliath pit and the northern portion of the Six Mile Well pit were found to not host suitable subterranean fauna habitat. Dewatering will be limited to the extent that is required for mining to occur. **Rehabilitation** The specific rehabilitation of subterranean fauna habitat has not been attempted before and will not be attempted for the Goliath and Six Mile Well pits. Post cessation of mining, Six Mile Well pit will be completely backfilled so groundwater levels will return close to baseline levels in the long term. **Likely Rehabilitation Success** It is not expected that the depauperate subterranean fauna environmental values would return within the backfilled pit area. However, outside of the backfilled mine pit within the groundwater drawdown impact zone, subterranean fauna environmental values are considered likely to recover with natural restoration of groundwater levels.	**Residual Impact** The proposed development of the Goliath and Six Mile Well pits are not considered to represent a significant residual impact to the stygofauna values recorded from parts of the Study Area. Under the residual impact significance model the proposed areas of impact associated with the development of Goliath and Six Mile Well pits are not recognised as hosting high biological values or representative of high biodiversity. In addition, the proposed impacts are not considered likely to result in any subterranean species being listed as specially protected or threatened. The Project is considered to not pose a risk to the long-term survival of any known troglofauna species as no species were collected from the within the proposed impact areas. For stygofauna, the two stygobitic species, *Atopobathynella* sp. OES11 and *Gomphodella* sp. IK2, recorded from within proposed Six Mile Well groundwater drawdown impact areas only, are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The broader distributions of both species are supported by the wider distribution of *Atopobathynella* sp. OES8 and relatively high haplotype diversity of *Atopobathynella* sp. OES11 that concur with the hydrogeological information that the habitable portion of the Six Mile Well regolith aquifer system is hydraulically connected to a network of other regolith and fractured rock aquifers associated with the upper Jones Creek catchment that extends at least to the non-impact zones within the Goliath Proposal Area; and broader distribution patterns exhibited by *Atopobathynella* and *Gomphodella* species documented in other studies. The development of the Six Mile Well and Goliath pits and associated dewatering is considered to not pose a long term conservation risk to stygofauna and the EPA objective for this factor can be met. **Offsets** No offsets are proposed as no significant residual impacts are considered to occur to the stygofauna values present in the study area.
Potential Indirect Impacts: Changes to groundwater quality and chemistry through increase in sediment load in run-off from mine associated activities into tributaries leading to reduction in surface to groundwater infiltration rates lessening influx of resources (e.g. nutrients, oxygen); and Contamination of groundwater by fuel spills.	**Avoid & Minimise** Construction and maintenance of surface water drainage systems to control and contain run-off from mining areas and divert clean stormwater away from pits and other mining disturbance areas. Drainage alongside transportation corridor to control run-off and divert clean stormwater away from access ways and topsoil stockpiles. Fuel storage to be maintained with self bunded facilities. Hydrocarbon contaminated soil and materials to be removed for disposal or remediation Avoidance of Jones Creek riparian zone other than for creek crossings. **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	

8 Hydrological Processes

8.1 EPA objective, policies and guidelines

The EPA's objective for hydrological processes is:

> *"to maintain the hydrological regimes of groundwater and surface water so that environmental values are protected."*

Hydrological processes are defined by the EPA, for the purposes of EIA, as "*the occurrence, distribution, connectivity, movement, and quantity of water".*

The focus of this factor and its associated objective is on how any alteration of hydrological regime significantly impacts on water dependent ecosystems and other values supported by groundwater and surface water.

The policy and guidance documents considered in the environmental impact assessment for this factor are listed in **Error! Reference source not found.**. The ERD is consistent with these documents.

Table 41 Policy and guidance relevant to Hydrological Processes

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Hydrological Processes (EPA, 2016).	Outlines how the EPA considers subterranean fauna in the EIA process, including how this factor links with other environmental factors.	The ERD describes the surface hydrology and groundwater hydrogeology of the Proposal Area in local and regional context. The Proposal is located within a semi-arid zone, where surface flows are ephemeral and groundwater is limited due to geology. Regionally the Proposal is located within the Lake Miranda catchment, and locally is located within the upper catchment of Jones Creek. The Proposal pits will intersect groundwater resources. Water supply for the Proposal will utilise all dewatering volume in addition to source from the existing NMK. Modelling of impacts on surface water flow and groundwater during operations and post closure have been undertaken and mitigation measures are proposed. The ERD demonstrates that the development of the pits and the wider Proposal will not significantly impact on either the short or long term hydrological regimes of groundwater and surface waters, ensuring environmental values are maintained through the application of appropriate mitigation measures. NiW considers that the EPA's objective for hydrological processes can be met.
Other Policy and Guidelines		
Operational policy No. 5.12 – Hydrogeological reporting associated with a groundwater well licence (DoW, 2009).	Provides guidance on when hydrogeological assessments and groundwater monitoring reports (collectively referred to as hydrogeological reports) will be required, and the information that they should contain.	NiW has undertaken a detailed hydrogeological assessment of the Proposal (Appendix N) consistent with these guidelines, which will inform relevant groundwater licensing, ongoing monitoring and reporting requirements under the RIWI Act.
Western Australian water in mining guidelines (DoW, 2013).	Provides guidance on how to meet regulatory requirements for mining Proposals, particularly with respect to licensing under the Rights in Water and Irrigation Act 1914 (**RIWI Act**).	

8.2 Receiving environment

MWES Consulting were commissioned by NiW to undertake an assessment of the baseline hydrological and hydrogeological regimes and identify potential impacts associated with the Proposal. Their findings are provided in Appendix N and described in the following sections.

BASELINE SURFACE HYDROLOGY

The climate of the Mt Keith region is described in Section 2.4.

The geology of the Proposal Area, as described in Section 2.4, is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite, which host the nickel sulphide deposits (MWES Consulting 2017b).

Regional hydrology

Figure 46 shows the Proposal area in relation to regional catchment features. The Proposal is located in the Lake Miranda catchment. The north-east side of the main valley is formed by the Barr Smith Range, in which are located the existing and proposed satellite pits. The upper slopes of the Range are sparsely vegetated, rocky and relatively steep. From the catchment divide at altitude 550 -580m AHD down to about 515 m AHD, drainage line gradients are typically 1-4%. The short ephemeral creeks which drain the sides of the Range flood out onto the sedimentary deposits on the lower slopes of the valley. These minor lateral tributary creeks mostly terminate several kilometres short of the valley floor in vegetated distributary alluvial fans (flood-outs). Jones Creek drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to a Claypan near the valley axis.

Local hydrology – Jones Creek

The Proposal is located within the upper catchment of the Jones Creek which is a lateral tributary system, incised into the Barr-Smith Range, at an altitude of approximately 520-560m AHD. The catchment is relatively efficient in terms of yielding stormwater run-off to the main stream. Surface gradients are relatively steep by regional standards, due to presence of a sequence of low strike ridges within the upper catchment. The rocky nature of the terrain with little alluvial or residual soil cover and sparse low vegetation further enhances the tendency for the catchment to shed rather than store water, which is evidenced by the dense array of well-defined and well incised minor tributaries and the relatively broad and coarse gravel bearing main-stream. This is also reflected in the flash-flooding type of creek flows generated by the catchment (MWES, 2017).

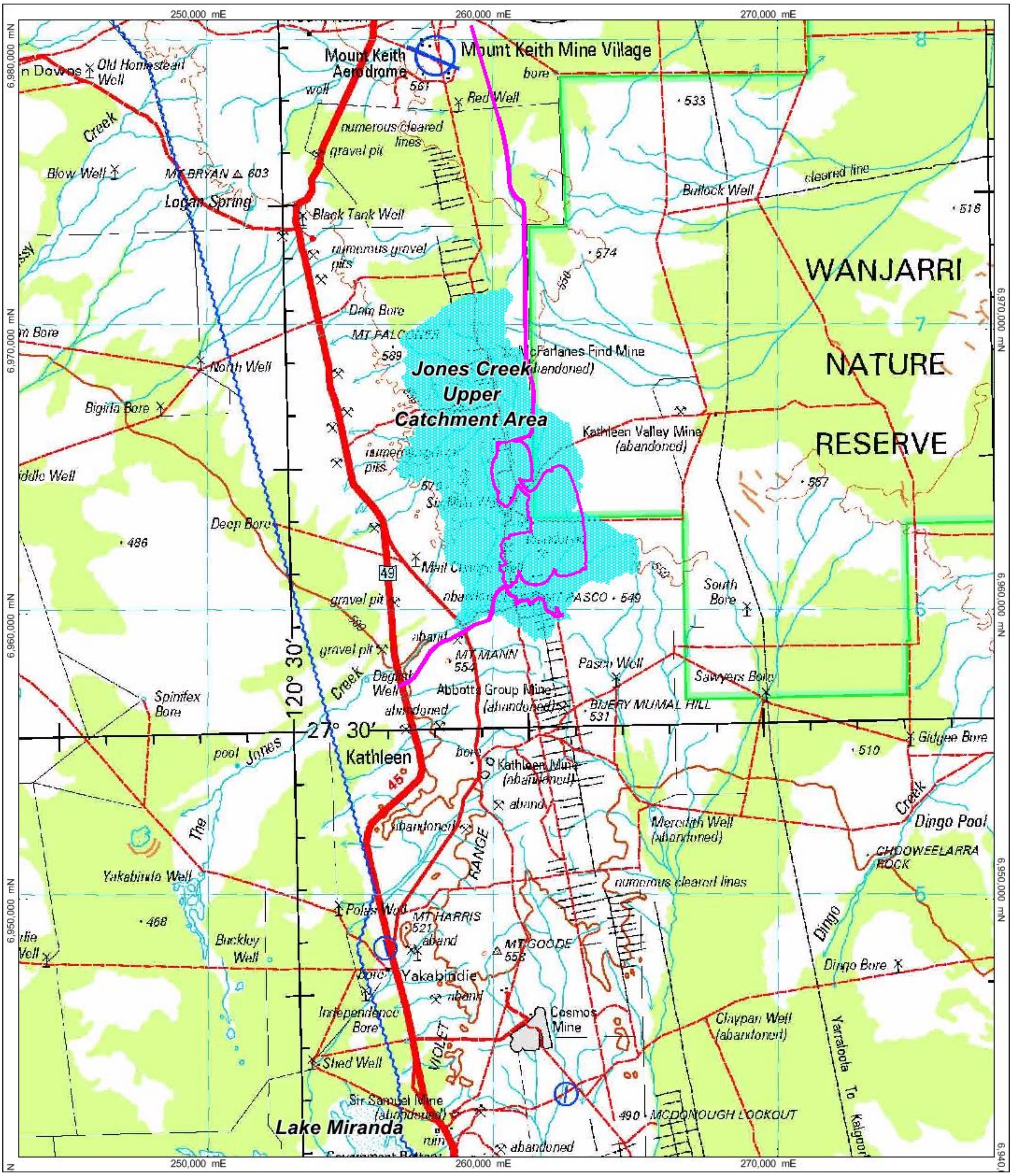
In a local and regional context, the majority of runoff for this ephemeral water course is received from the upper steep, rocky and poorly vegetated portion of the Jones Creek catchment. The terminus for the creek is a large floodplain area to the south west, containing a number of claypans (MWES Consulting 2017b). Beyond this, drainage becomes increasingly diffuse, before encountering the Yakabindie calcrete and reaching Lake Miranda, located within the Carey Palaeodrainage system (Wetland Research and Management 2005, Stantec, 2017b).

MWES Consulting have undertaken regional stormwater runoff modelling and peak flow rates calculations for Jones Creek which were then used to model peak flood level calculations to assist in planning stormwater management controls (Appendix N). Figure 47 shows the extent of the modelled peak flood levels for 1:100 and 1: 1000 year events. Apart from the two Jones Creek crossings there are only minor proposed incursions of the Proposal Disturbance Footprint (red polygon) into the extreme flood zone, for which controls required to manage interactions and impacts are discussed below.

Jones Creek is reported anecdotally to flow from moderate to high intensity rainfall of 25 mm or more. The catchment yield was simulated using a simple one-day time-step model, using daily rainfall total and event duration (hours), and includes initial and ongoing rainfall losses and catchment storage depletion by evapotranspiration. The adopted parameters were based on local observation, anecdotal evidence and regionally derived parameters (MWES Consulting, 2017b).

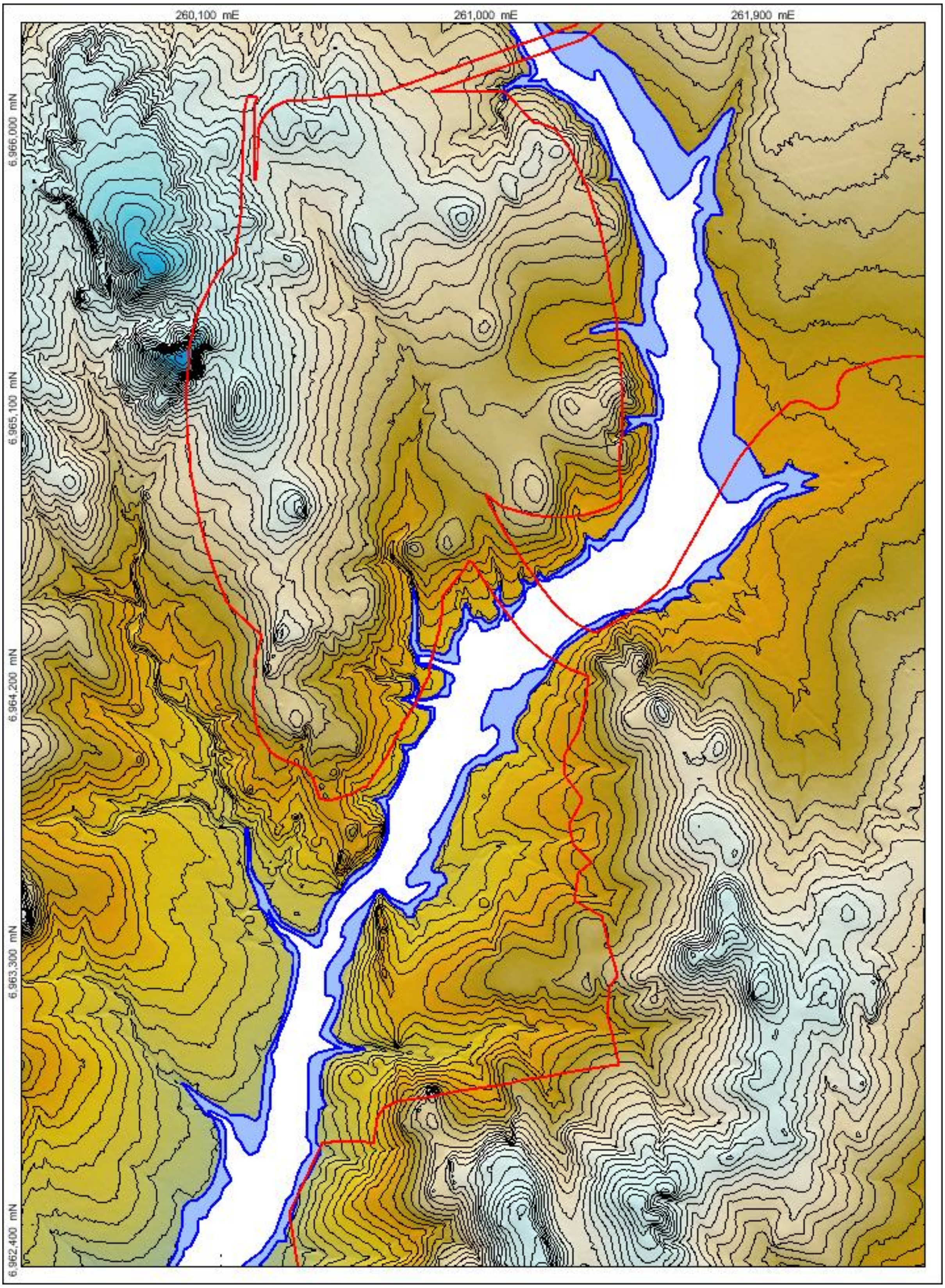
Modelling of the baseline 64.1 km2 catchment area produces a 1:100 year runoff record with the following characteristics:

Flow days (whole creek to claypan)	81 per 100 years
Flow events (i.e. separated by > 1 day)	76 per 100 years
Years in which Claypan flooded	49 per 100 years
Median annual yield in flow years	1168 ML/a
Probability of fill to 1.25 m depth	36 % in any year
Probability of fill to 0.5 m depth	43 % in any year



MWES Consulting 2017b

Figure 46 Proposal area and regional catchment features

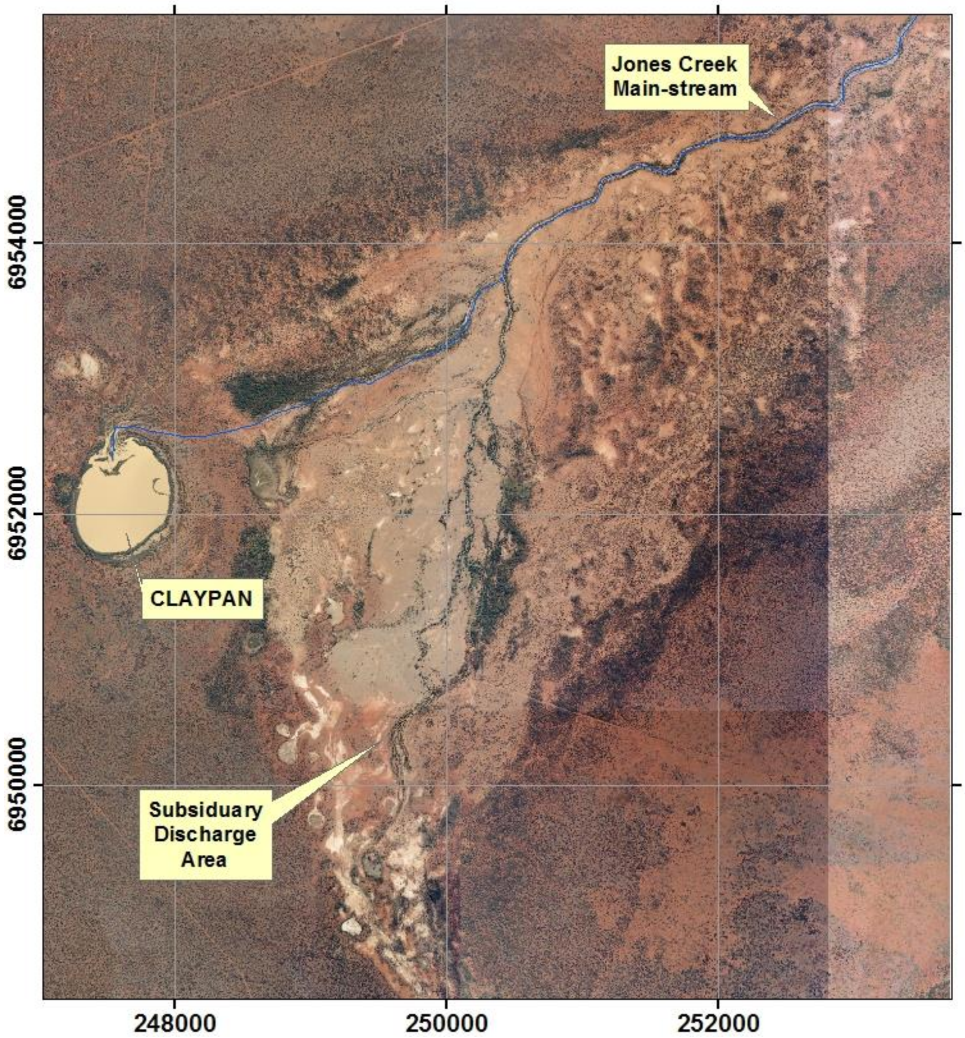


MWES Consulting 2017b

Figure 47 Peak Flood Levels for 1:100 (white) and 1:1000 Year Events (blue)

Jones Creek Discharge Area

The terminus for Jones Creek is a large floodplain area in the valley floor to the south west, containing a number of claypans. Figure 48 shows that high flow distribution of the stream flow starts about 7 km upstream from the Clay-pan where there is overbank discharge to the south. The creek bifurcates 3 km upstream of the Clay-pan, with the subsidiary channel discharging to a heavily wooded area and collection of minor clay-pans. For low to moderate flow events the large majority of volume reports to the main clay-pan, with southern discharge only at very high water levels and /or after the Clay-pan fills and water levels back up the main channel. (MWES Consulting, 2017b).



MWES Consulting, 2017b

Figure 48 Jones Creek discharge area and terminal clay-pan

The Claypan holds water and sustains a fresh-brackish water ecosystem for several months after stream flow events which is unusual in the Northern Goldfields. The low water salinity and unusually long “hydro-period” defines its potential significance as a habitat or ecological water resource. The potential impacts of the development on the Clay-pan arise from the reduction in catchment area due to the excavation of pits (zero run-off) and construction of waste dumps (practically zero run-off). During extreme rainfall events the Clay-pan fills to overflowing negating any effect of reduced catchment yield. For the more common low – medium intensity rainfall/runoff events, the reduced catchment yield will reduce the volume in storage in the Clay-pan. It is for these smaller and more common (nominally 1 in 2 year to 1 in 5 year average recurrence interval events) that the potential impacts of catchment area reduction will be greatest. After a flow event, storage in the Clay-pan is gradually depleted by evaporation and seepage. Therefore, any reduction in catchment yield will reduce the initial and average depth of water in the Clay-pan and therefore the duration of inundation.

The 100-year, on-day time step whole catchment yield model described above was adjusted to provide an estimate of flow duration statistics in the upper catchment as a result of Proposal Disturbance Footprint. Loss parameters were adjusted to reflect the upper catchment differences and provide a conservative (high) estimate of flow duration as a basis for consideration of operational impacts assessment and to provide conservatism. The duration for individual flows was estimated on an hourly basis as the duration of the rainfall event plus 4 hours (when rainfall minus losses exceeds threshold for flow) which is based on observed hydrographs and unit hydrographs for similar “peaky” catchments. The results indicate:

- Small flows may be limited to the upper catchment and not result in discharge to the Claypan.
- The shorter hourly basis appropriate to the upper catchment captures additional brief and smaller flows.

In context of impacts assessment, model loss parameters used in the yield simulation are conservatively high and in the flow duration simulation parameters are conservatively low.

Baseline stream water quality

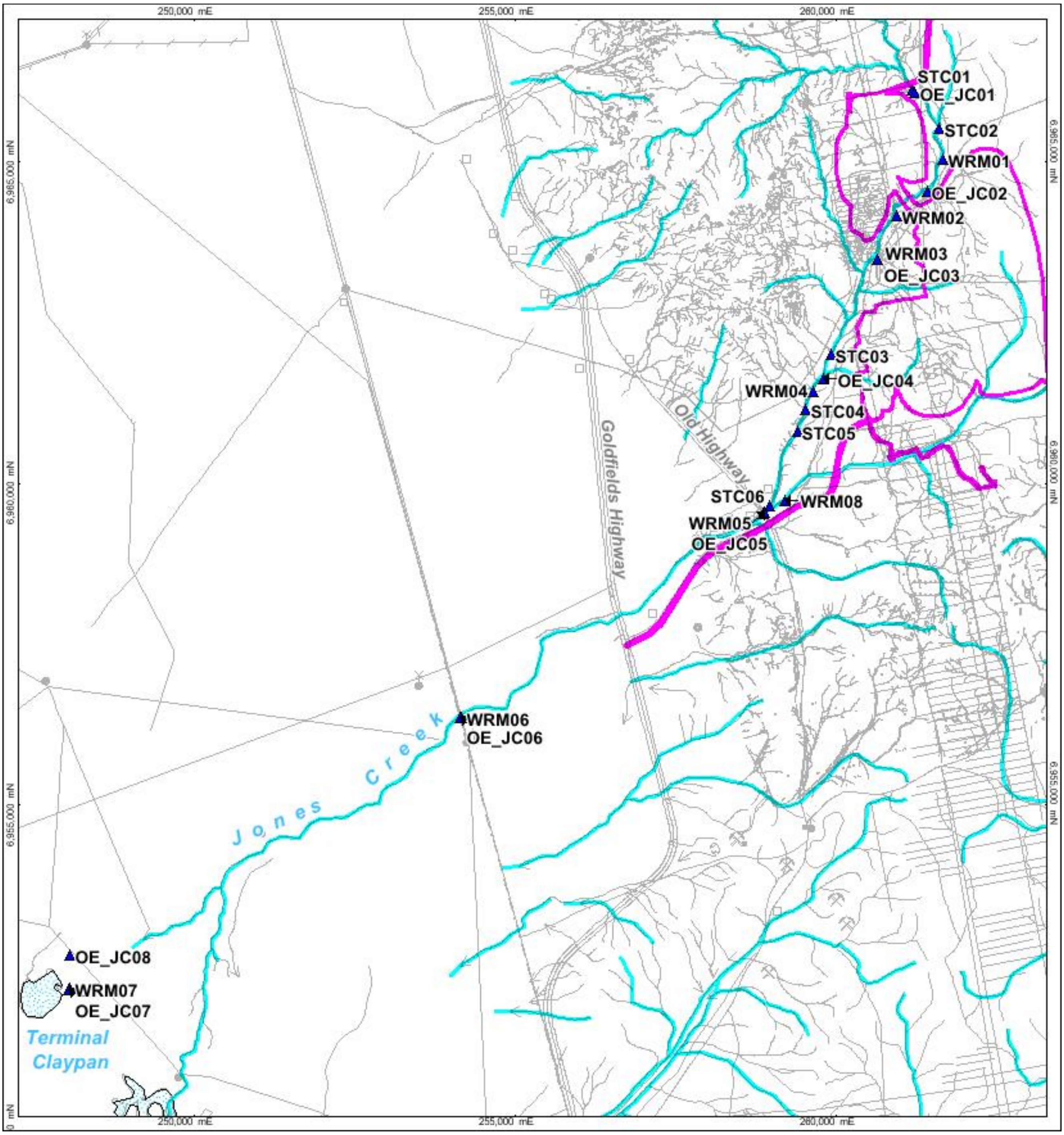
The brief (duration measured in hours) and infrequent flow events within the Jones Creek catchment combined with the remote location have limited opportunities for stormwater runoff sampling. This, in addition to the high variability of runoff patterns during particular flow events, as well as the large range in duration and rainfall patterns between, provide complexity in the determination baseline flow water quality.

Baseline surface water quality sampling has been from residual ponds after flow events and three programs have been undertaken, with locations shown in Figure 49.

Sampling from stagnant pools one month after a flow event (Figure 49, locations STC01 to 06) showed low salinity (40-121 mg/L) and low turbidity. Concentrations of most trace metals (cadmium, copper, nickel and lead) were mostly below detection levels, noting however the relatively high copper detection limit (20 µg/L). High iron and manganese concentrations were ascribed to natural leaching from sediments in anoxic conditions.

Further stream pool sampling was undertaken on 18-20 May 2005 (Wetland Research and Management, September 2005, Appendix N) after the flow event of 5 May described above. Stream pool salinity was less than 100 mg/L. Nutrient levels were found to be elevated presumably due to pastoral impacts, with total nitrogen, (up to 2.4 mg/L), nitrate (up to 1.9 mg/L) and total phosphorus (up to 0.06 mg/L) exceeding ANZECC (2000) trigger levels. Arsenic, cadmium, chromium mercury, lead and selenium concentrations were at undetectable to extremely low levels. Copper, nickel and zinc were consistently detectable and copper concentrations at 3-7 µg/L, exceeded the ANZECC (2000) 80% protection trigger level of 2.5 µg/L.

Two rounds of water sampling were undertaken at six creek sites and one Claypan site in early 2011, (Outback Ecology, 2011) about 6 and 8 weeks after creek flows. Results were consistent with the previous sampling. The creek samples were non-turbid and of less than 170 mg/L salinity. Nutrients were again found to be elevated with total nitrogen in the range 0.6-2.1 mg/L and total phosphorous up to 0.06 mg/L in stream sediments and up to 0.19 in the Claypan samples. Of the broad range of trace analytes assessed, only aluminium, barium, copper iron and nickel were routinely detectable. Stream pool copper concentrations were up to 13 µg/L and 7 of 10 samples exceeded the ANZECC (2000) 80% protection trigger level of 2.5 µg/L. The Claypan samples were fresh but turbid, one of two samples slightly exceeded the copper trigger level and both samples (1.13 and 1.63 mg/L), exceeded the 80% protection trigger value of 0.15 mg/L for aluminium.



Legend:

WRM – stream pool sampling locations

OE – creek and clay pan sampling locations

MWES Consulting, 2017b

Figure 49 Surface water sample locations

Baseline stream sediment characteristics

Due to the complexity of factors impacting on stream water quality, additional control on surface water impacts assessment can be achieved by reference to baseline stream sediment characteristics, which can potentially provide a more robust indicator of impacts.

Descriptive and quantitative assessment of the stream sediment at four sample reach sites and at the terminal clay pan was undertaken by SKM (May 2005).

Particle size distribution (PSD) curves for sediments from each of the four creek transects were similar. Three samples from within the main channel classed as medium-grained sand with more than 85% sand sized particles and up to 1.2% clay sized particles. The two claypan PSD samples classed as very fine silt with 17-25% clay content.

Chemical analysis of the sub-106 micron fraction (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) showed total metals concentrations to be generally well below the sediment quality guideline low trigger value for aquatic ecosystems (ANZECC, 2000). Nickel and chromium concentrations were close to the lower trigger value and substantially below the upper trigger value. These levels are considered typical concentrations for soils associated with un-mineralised greenstone belt rocks of the WA Goldfields.

Sediment samples taken in 2011 were from overbank positions at the locations shown on Figure 49 (Outback Ecology, 2011) and were not subject to size-fractionation. The elemental composition results were similar to the 2005 results with most of the potentially soluble and toxicologically relevant metals being at very low concentrations compared to ANZECC trigger levels except chromium and nickel. Chromium concentrations ranged from 26-210 mg/kg, mostly between the ANZECC low and high trigger values (80 and 370 mg/kg) while nickel concentrations were in the range 4-36 mg/kg, generally lower than the 2005 samples and mostly below the low and high ANZECC trigger values (21 and 52 mg/kg).

Baseline hydrogeology

The geology of the Proposal Area is of Archaean greenstone belts of the Yilgarn Craton comprising a faulted and folded NNW-striking, near-vertical layered sequence of high grade metamorphic sediments and volcanics and early felsic intrusives. Ultramafics are mostly peridotite-rich (high aluminium, fixed silica and low porosity). Nickel sulphide mineralisation is associated with lozenges of adcumulate ultramafic or dunite (olivine rich, low aluminium, silica leaching and high porosity upon weathering). The major host rock is mapped as porphyritic felsic and includes dacite and andesite. The Six Mile Well pit geological setting is more complex than the Goliath Pit, with a cross-cutting fault truncating the southwest side of the host ultramafic and layers of metasediments and basalt in the host rock sequence.

There is little alluvial or soil cover. The regolith profile is relatively shallow being truncated by surface erosion. Thinner weathering occurs over the felsic-intermediate rock types with maximum thickness (highly weathered materials up to 60 metres thick) over the dunite bodies where the profile comprises:

- Oxide ferruginous – clay altered, local hard pan and nodular iron.
- Oxide silica-carbonate – complete oxidation, serpentinite, irregular silicification and carbonate alteration.
- Supergene – partial oxidation towards top, serpentine bleached and porous.

At Six Mile Well, the dunite pod has dimensions of 1500 x 400 m and is nearly vertical. The upper ferruginous oxide is up to 10 m thick. The oxide zone rich in secondary silica-carbonate is patchy depending on original parent rock type as above. The base of Supergene (oxide and transitional material) is at a depth of 90 m to 170 m (360-440 m RL).

The Goliath ultramafic package is smaller, and wedge shaped with the footwall sub-vertical and hanging wall dipping to the west. There is a very thin regolith transition zone (oxide-sulphide) with base of oxidation at 30-70 metres depth.

Geochemistry

Investigations into the geochemical characteristics of the host rocks and low grade nickel ore have been reported by Graeme Campbell and Associates (2005, Appendix S), with the criteria established for potentially acid forming (PAF) material. The criteria for PAF being either:

- Sulphide-S ≥ 0.3 %, and any positive-NAPP value; or
- Sulphide-S ≥ 0.3 %, and a negative-NAPP value with ANC/MPA < 2.0;

where ANC is acid neutralising capacity, MPA is the maximum potential acidity (calculated by assuming complete oxidation of sulphide-S) and NAPP is net acid producing potential (calculate das MPA-ANC).

Generally the waste rock is expected to contain an abundance of sulphide minerals with a moderate to high ANC. A notable exception has been identified as the volcanic sediments unit which forms a portion of the Chert/Shale, for which samples have returned total-S in the range 2-16% and despite high ANC have been classified as PAF. The sulphidic material occurs in thin bands and very low volumes in both pits. The situation is similar to the Mt Keith where large scale mining and co-disposal with high ANC material limit the potential for acid leachate at any significant scale. The Mt Keith experience of waste rock management confirms site specific assessment that the large majority of unweathered waste rock is competent. The waste rock landforms are mechanically and geochemically stable and do not present a risk to surface or groundwater.

Within the talcose ores (transitional and fresh) and waste rocks within ore zones, there is the potential for soluble-Ni forms to be produced during circum-neutral weathering. Under semi-arid conditions this should be confined largely to the top 2-3 m of the stockpiles, as governed by seasonal moisture dynamics.

Groundwater occurrence

Groundwater is relatively scarce in the Proposal area. Based on experience at nearby Mt Keith Mine and Leinster where mines are located in similar geology and host/ore rock sequences, groundwater occurrence is enhanced by the weathering of the dunite (adcumulate) ultramafic ore with partial silica replacement in the regolith zone, creating a porous vuggy material, typically at depths of 40-60 metres. The aquifers are of limited lateral and vertical extent and surrounding rocks are of very low permeability. The typical dewatering history for these mines involves a higher rate of pumping to deplete the localised “reservoir” which then stabilising at low ongoing rates. Drawdown extent is localised to less than 1 km from the pit perimeter due to the absence of extensive interconnected aquifers.

The hydrogeology of the area has been evaluated in several phases commencing with the Dominion Mining Feasibility Study (1990). The latest hydrogeological drilling was undertaken in February 2017 and included 34 new monitor bores and the redevelopment (and re-naming) of 19 historical bores – these 53 holes are prefixed SMW (Six Mile Well) or GOL (Goliath). Figure 50 shows the locations of all hydrogeological drill sites and the currently proposed northern SMW and southern Goliath pit outlines.

The yield of hydrogeological drill-holes and bores is shown in Figure 51. Note that these are not representative of the typical rockmass conditions across the Proposal area, rather the results are strongly biased toward localised higher yielding zones due to targeting of features such as faults, lineaments and lithological contacts. Reviewing the distribution of drilling and the lithology from which yields were obtained (Appendix N) the following patterns are evident:

- To the south and west of Goliath Pit, yields were variable and obtained mainly from fresh ultramafics.
- In and near Goliath Pit yields were generally very low.
- In and near SMW Pit moderate yields were obtained from saprock ultramafic.
- In the SMW Pit (west) hanging wall basalt and metasediments there was very low yield.
- Minor yields were obtained from structural targets near the felsic/basalt contact east of the SMW Pit.

At the site-wide scale, the oxide zone over the dunite ultramafic pod at SMW constitutes the most extensive aquifer, where high permeability and porosity occurs in the oxide silica-carbonate zone which extends to about 50 mbgl. On a regional scale this is a small and localised “caprock aquifer”. Permeability and porosity diminishes with depth and degree of weathering below the main aquifer zone. Low to moderate permeability may also occur to a depth of 60 metres and in highly weathered materials formed in other ultramafic lithologies. No extensive aquifer has been found associated with the Goliath ore-body.

Other groundwater occurrences are isolated fractured rock aquifers occurring at structurally controlled locations within the pit areas and beyond. The fracture zone permeability may range up to moderate- high values, however the fault zones have low porosity and limited lateral extent, which means that storativity is 2 or more orders of magnitude lower than that held on the main Six Mile Well regolith aquifer.

Water levels

Water levels across the Proposal area are shown on Figure 52, and are based on measurements taken at the end of the 2017 drill campaign. At sites where no value is posted water levels remained depressed for months after drilling and development - an indication of very low rockmass permeability at that site.

Water levels are relatively flat across the area, particularly on the ultramafic bodies with many values in the range 504-505 m AHD. There is a slight hydraulic gradient south down Jones Creek away from the SMW pit.

Depth to the water table varies from a minimum of about 15 m near the southwest corner of the mapped area. In the bed of Jones Creek through the SMW pit, the depth to water is at least 16 -17m. Outside of the creek beds the depth to the water table is typically in the range 25-35 m. At such depths, it is considered that groundwater does not sustain surface vegetation. Due to the depth to water table and limited recharge potential, natural groundwater level fluctuations are likely to be minor and not relevant to the dewatering and impact assessment.

Aquifer confinement (or “submergence”) is important in determining drawdown response to pumping (dewatering). This can be calculated as the vertical difference between the standing water level and the top of the zone of groundwater yield in each bore (“top of aquifer”). Figure 53 shows this aquifer submergence for each bore and represents the thickness of the saturated low permeability confining materials overlying the aquifer.

If the aquifer zone is potential biological habitat (for stygofauna) then the submergence or confinement is of particular importance in determining the sensitivity to drawdown. For example an aquifer zone/habitat with a submergence of 20 metres (confined aquifer) would be insensitive to drawdown of up to 20 metres, whereas a habitat zone with zero submergence (unconfined or water table aquifer) is immediately impacted (partially depleted) by any drawdown.

At most bores the groundwater yield was obtained from a well-confined zone with submergence typically in the range 15-40 metres. The Six Mile Well dunite ultramafic is unconfined or semi-confined with submergence typically less than 10 metres.

Groundwater quality

Baseline groundwater quality samples were taken at the end of the development of each of the bores in the 2017 drill program for a total of 50 samples, with results summarised as follows (refer to Appendix N for results):

- The majority of sites show brackish groundwater with electrical conductivity (EC) in the range 1000-5000 uS/cm and a notably high degree of local variability of groundwater salinity.
- Bores intersecting the Six Mile Well dunite ultramafic aquifer have higher salinity - mostly in the range 5000-10000 uS/cm.
- Samples from sites GOL06, SMW04, SMW05, SMW13 (low yield bores) showed unexpectedly low EC, likely due to contamination with drilling water. These sites are considered unrepresentative.
- Groundwater is neutral to slightly alkaline and of sodium chloride type

- Concentrations of dissolved cadmium, chromium, lead, selenium and zinc were mostly below detection limits.
- Concentrations of most other trace components were also at very low levels compared to ANZECC guidelines for aquatic ecosystems (2000).
- Elevated boron concentrations are widespread and particularly associated with the Six Mile Well ultramafic at up to 4.7 mg/L.
- Nickel (and to a lesser extent chromium) concentrations are slightly elevated on the Six Mile Well dunite with nine samples having an average dissolved nickel of 0.11 mg/L and average total nickel of 0.19 mg/L.
- Nutrient levels show moderate nitrate concentrations typical of arid regions of Australia and with low phosphate concentrations
- Trace element chemistry meets the ANZECC guideline values for livestock supplies
- Salinity is generally suitable for livestock supplies although some higher values exceed recommended long term supply guidelines for cattle.

As mining progresses, the main aquifer will be gradually depleted and groundwater originating from deeper more isolated fracture systems will constitute an increasing proportion of pit pumpage (during periods of dry weather). The groundwater salinity is expected to gradually increase after the first two years of mining, then stabilise with pumping rates.

Groundwater connectivity

The greenstone belt geological sequence hosts a generally sparsely distributed network of discrete minor confined aquifers – typically as steep, narrow linear structural zones. Water level data indicates a degree of interconnection between these features, albeit at a low level. Geological mapping and hydrogeological experience from Leinster to the south and Mt Keith to the north indicates that the distributed array of permeable fracture is likely to be continuous for tens of kilometres north and south of the Proposal site.

This is consistent with the findings of Section 7, where two stygofauna species (Atopobathynella sp.OES11 and Gomphodella sp. IK2) recorded from within Six Mile Well groundwater drawdown impact areas, are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections. These connections are considered to extent between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system.

At the given water table depths of 15 to 35m, it is considered that surface vegetation is not groundwater dependent. The further vertical confinement of the aquifers and the degree of variability of groundwater yield and salinity further supports the interpretation of low interconnectivity of surface and groundwater.

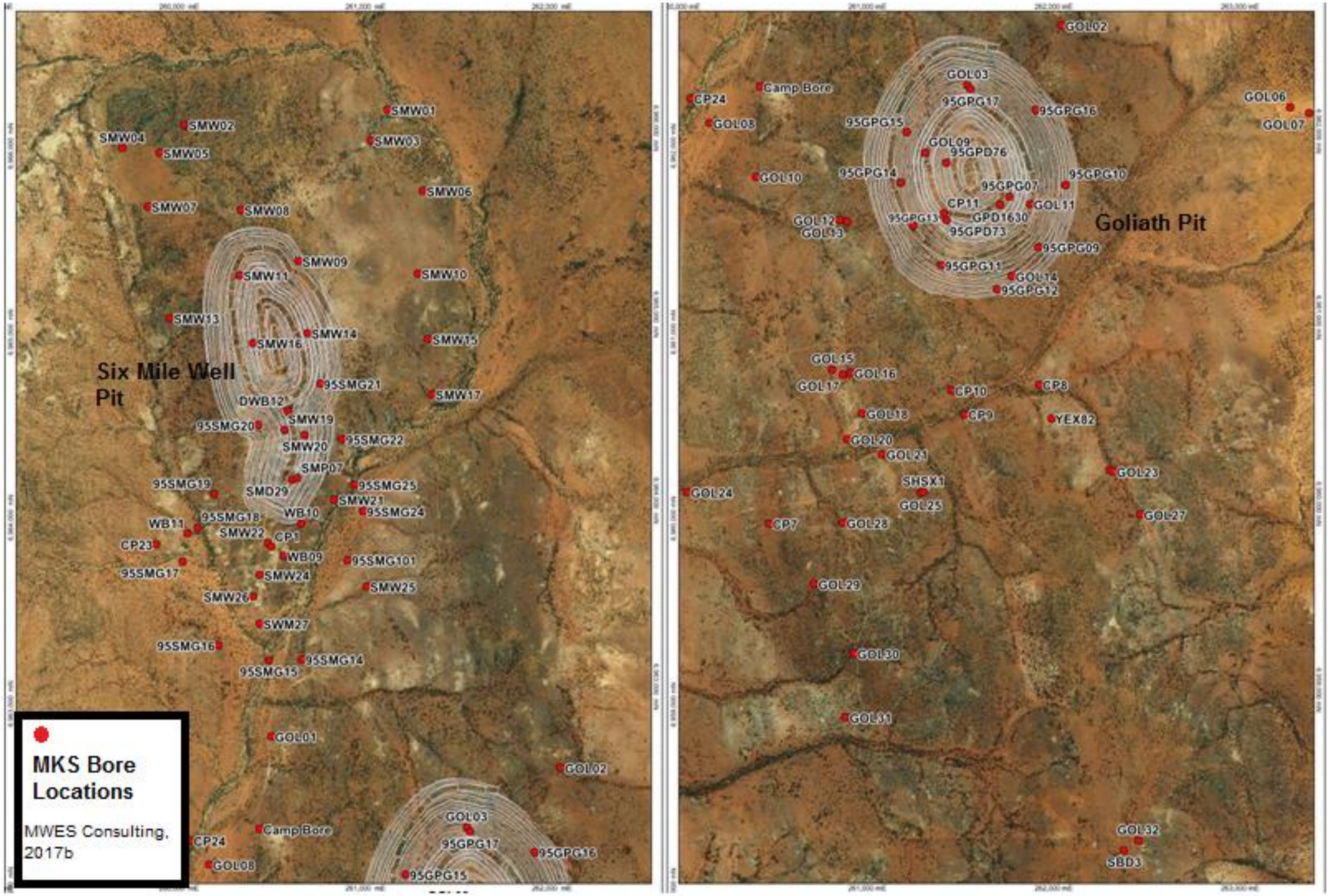


Figure 50 MKS Bore Locations

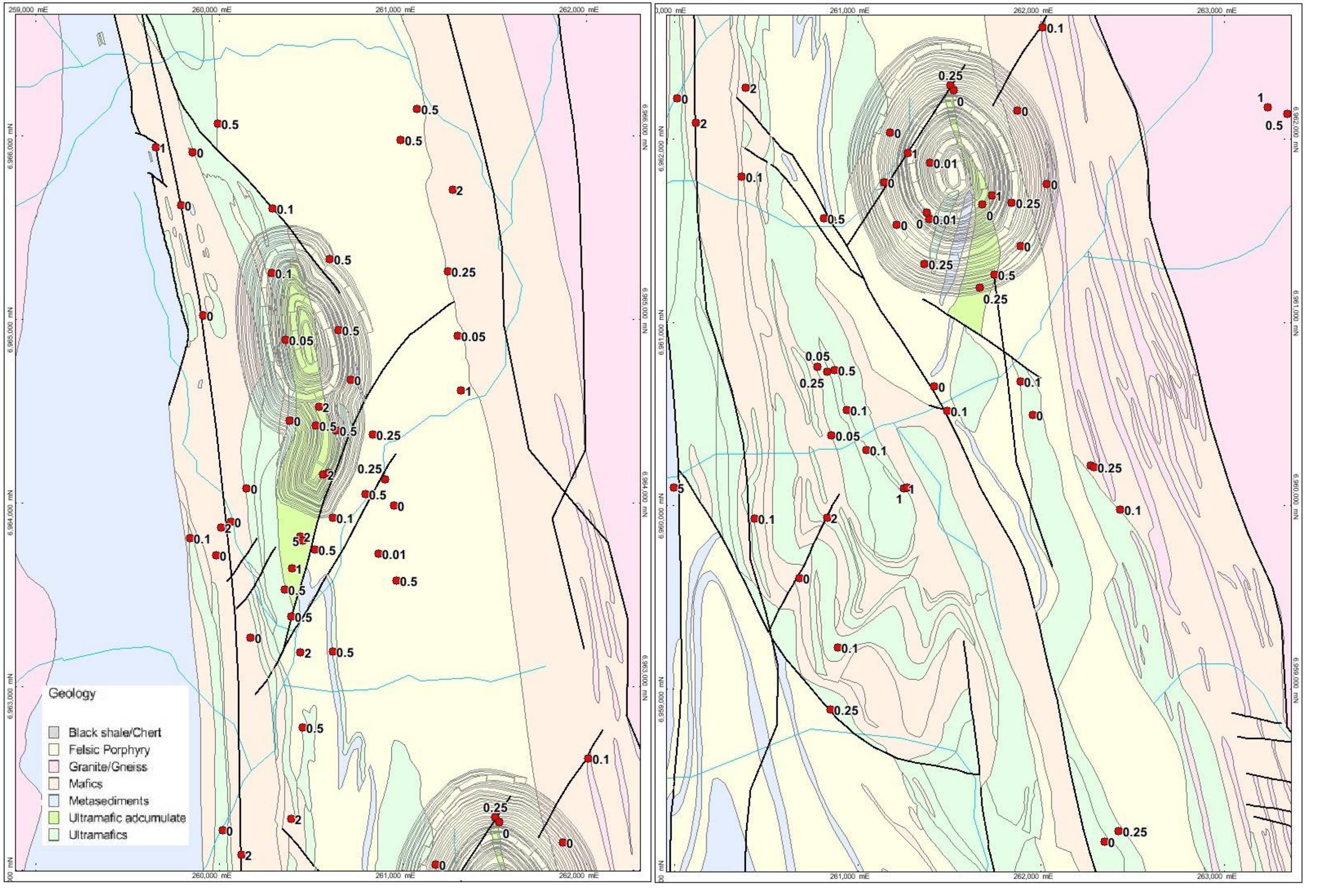


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Figure 51 Groundwater yield

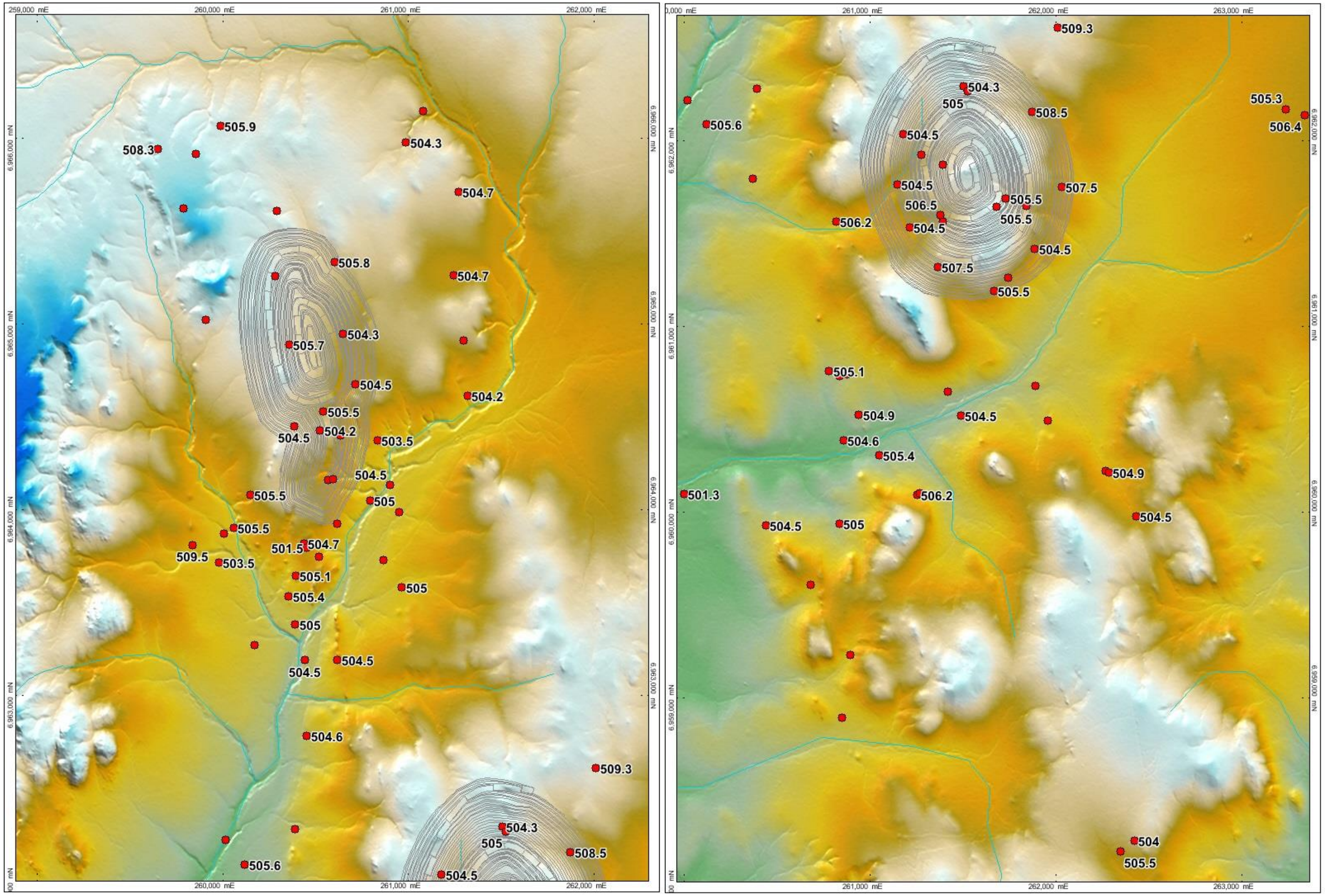

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Figure 52 Bore water levels (metres AHD)

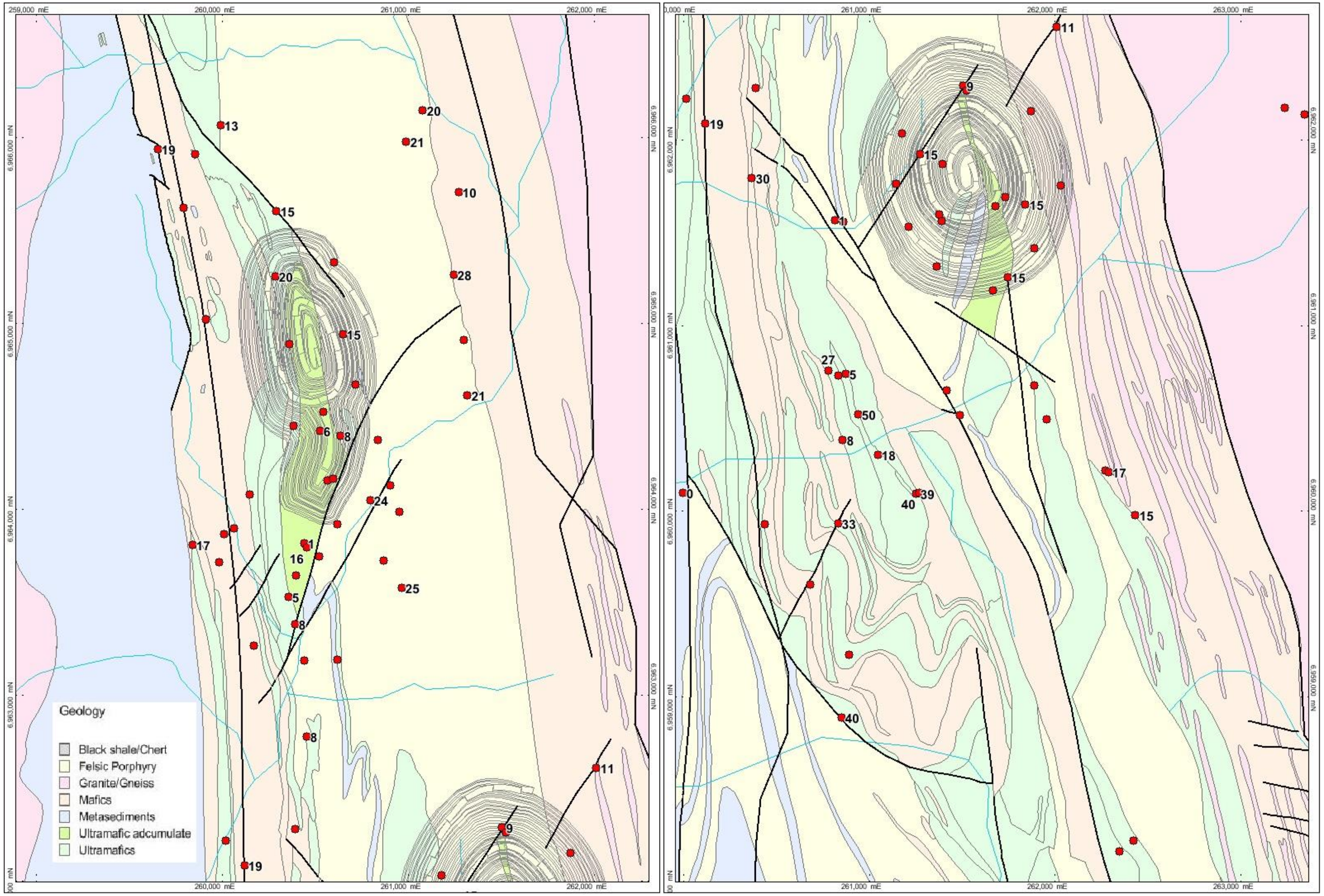

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Figure 53 Aquifer submergence (depth from water table to aquifer top, meters)

8.3 Potential impacts

The potential impacts and risks associated with changes to hydrological processes as a result of the implementation of the Proposal, include:

- Impacts to the natural surface water flow as a result of placement, design and operation of mine pits and associated infrastructure.
- Impacts to surface water resources, including Jones Creek, from alterations to surface water flows.
- Impacts to surface water resources, including Jones Creek from groundwater drawdown.
- Impacts to subterranean fauna as a result of groundwater drawdown and mounding.

8.4 Assessment of impacts

Alteration to surface water flows

The pit voids will retain all incident run-off and the waste rock landform run-off will be restricted by design. MWES's catchment model was used to determine the impacts of the reduced catchment area on creek flow frequency and magnitude, with a predicted reduction in baseline catchment area from 61.8 to 56.9 km^2 (8%).

The baseline and post closure annual yield frequency as determined by the catchment modelling is shown in Figure 54 and Table 42 summarises the impacts on key volumetric parameters.

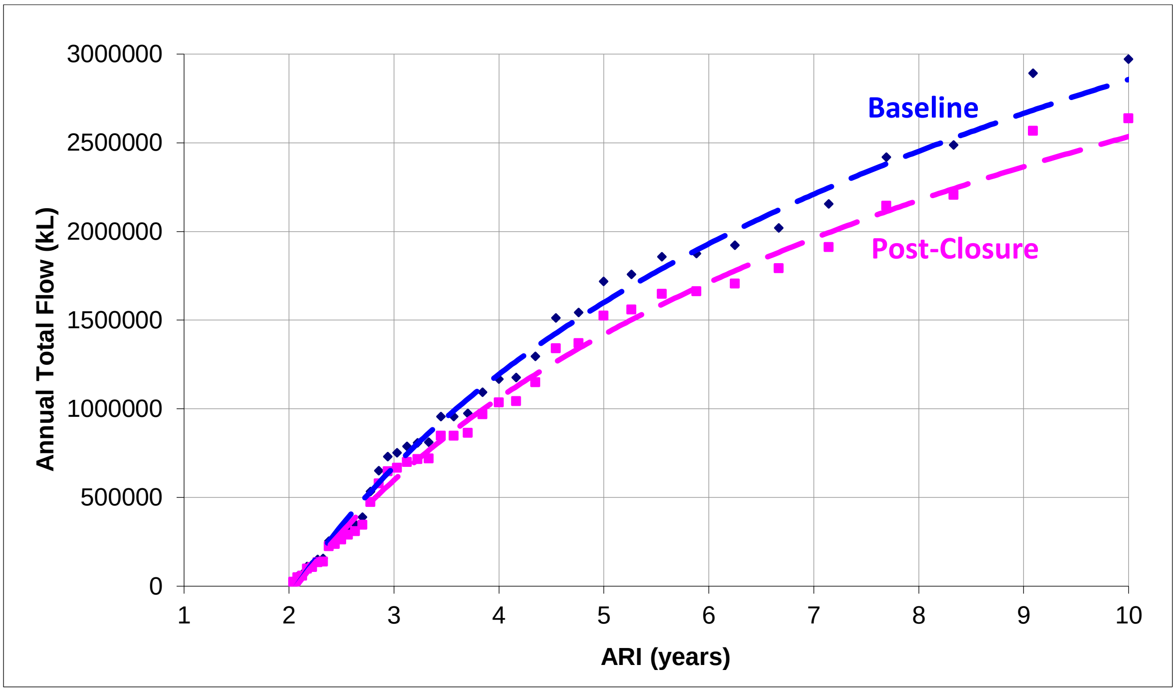


Figure 54 Baseline and post-closure annual yield frequency

Table 42 Impacts on streamflow and catchment yield

PARAMETER	Baseline	Post-Closure
Flow Days	81	81
Flow Events (separated by more than 1 day)	76	76
Years in which flow occurred	49	49
Median total annual flow in flow years (ML)	1168	1036
Probability of fill to more than 1.25 m depth (%)	36	35
Probability of fill to more than 0.5 m depth (%)	43	42

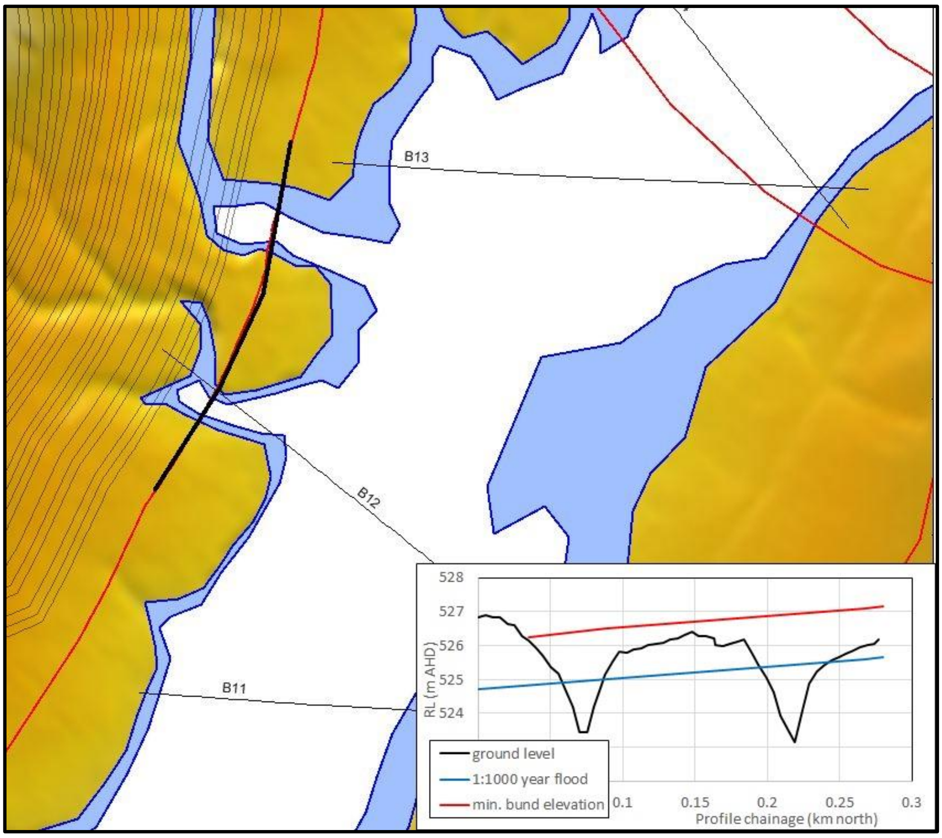
The model shows that the 100-year sequence of rainfall generates the same sequence of slightly smaller creek flows. There is a slight reduction in the frequency of flows above a given threshold – e.g. a 1% reduction in the annual probability of total flows exceeding the full capacity of the claypan (about 500,000 kL). There is a greater reduction in the frequency of very large annual streamflow totals, e.g. the average recurrence interval for an annual total of 2,500,000 kL declines from 12% (1:8 year) to 10% (1:10 year).

Due to the relatively high rainfall magnitude/intensity threshold before large scale runoff occurs in the catchment and due to the small volumetric capacity of the Claypan relative to typical flows, the frequency of filling is not substantially affected by the proposed development. Flows will continue to occur at a frequency 1:2 years and the median annual flow (in flow years), whilst reduced by 11%, remains more than double the full volume capacity of the Claypan. On this basis, no active controls are required to manage this impact.

Jones Creek stream flow

Figure 47 shows the estimated 1:100 year and 1:1000 year average return interval flood levels, along with the limits of the area of disturbance associated with the development. This figure shows some incursion of the 1:100 year flood zone into the Disturbance Footprint immediately south of the southern creek crossing, on the west side of creek at the south east corner of Six Mile Well pit. It is necessary to eliminate any possibility of creek flood flow entering the pits during operations to ensure a safe work place. In addition, the closure design must ensure that peak flow is not “captured” by the pit to avoid loss of through-flow to the downstream catchment.

The flood extent near the Six Mile Well pit is detailed in Figure 55. This figure shows the hydraulic flood model cross section lines (B11-B13), the limits of the disturbance and the limits of the pit. The limit of disturbance line is also the location of the pit abandonment bund, a standard operational and post-closure feature mandated by DMIRS. Also shown is the surface profile along the limit of disturbance/bund alignment, which demonstrates that DMIRS standard 2 m high bund wall construction would be above the 1:100 year flood level. Hydraulic modelling shows that stream flow velocities will be less than 0.5 m/sec at the bund wall and will not pose a severe erosion risk. To ensure adequate safety factor and integrity of the bund wall in this location, additional controls including additional bund elevation to 1.5 metres above the 1:1000 year ARI flood level; and compacted coarse rock cladding to ensure long term integrity.



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White depicts 1:100 year flood extent

Blue depicts 1:1000 year flood extent

Figure 55 Jones Creek peak flood extent near the Six Mile Well Pit

Two creek crossings will be required to facilitate movement ore from the ROM pad to the Mt Keith concentrator via the haul road (northern crossing) and movement of waste frock from the Six Mile Pit to the waste rock landform and ore from the Goliath Pit to the ROM pad (southern crossing). Flow modelling and modelling has indicated a "flashy" nature of stream flows in Jones Creek, i.e. brief (duration measured in hours) and infrequent flow events. The annual average is for 3 flows of duration of 8 hours, with the majority of the flow duration being at relatively low flow rate (< 5 m^3/sec).

The surface profiles and major flood elevations are shown in Figure 56 and demonstrate that the slope of the natural ground surface exceeds 8% over a maximum of approximately 30m horizontally on the west side of the main crossing, requiring very minor cut-backs to achieve suitable grade. More common high flow events (1:10 year average frequency) impact short sections of roadway (less than 50m).

Considering the low frequency and short duration of flow events, and in order to minimise impact on creek flow, a creek level floodway is considered the most appropriate creek-bed crossing. The creek crossings will have the following features:

- Minimum build-up of road surface above natural creek level in mainstream.
- Bed level concrete slab through main channel (up to 20 m long).
- Rock gabion protection buried to bed level on upstream and downstream side of slab.
- Coarse rock armouring of the bank cut sections up to the 1:100 year flood.

- Best practice to minimise vehicle tracking of clayey oxide material during wet periods including:
- construction of roads with appropriate compatible materials;
- road drain and surface maintenance to avoid build-up of sediment on roadways; and
- wheel wash as appropriate.

The construction of the floodway crossings is not considered to significantly alter Jones Creek flow volumes.

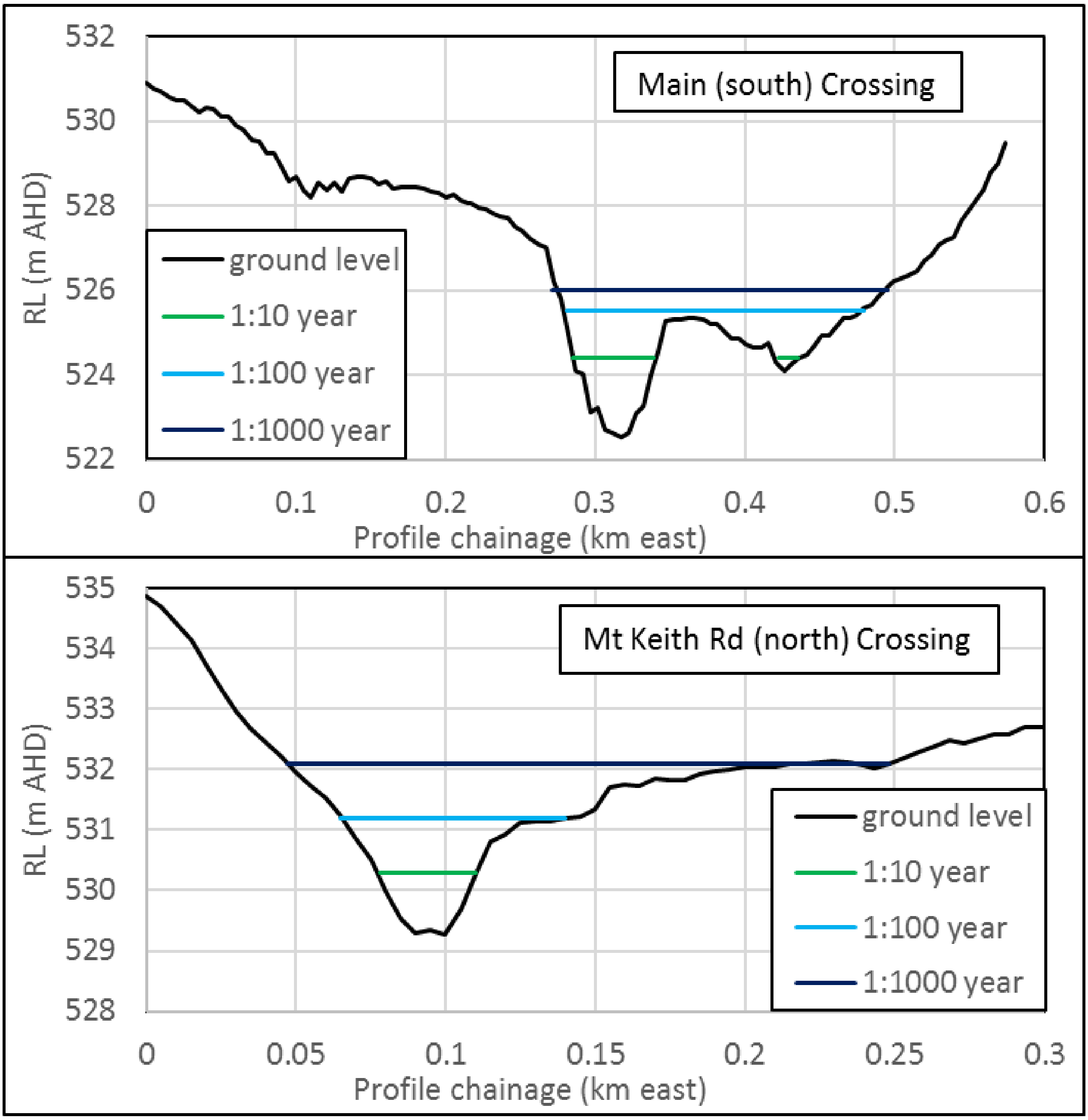

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Figure 56 Jones Creek crossing profiles

Haul road

The total distance of the haul road from the Jones Creek crossing (northern crossing) to the northern end of the Proposal area is 15km. The profile of the surface elevation along the route is shown in Figure 57 and the location of the route with respect to catchment drainage is shown in Figure 58.

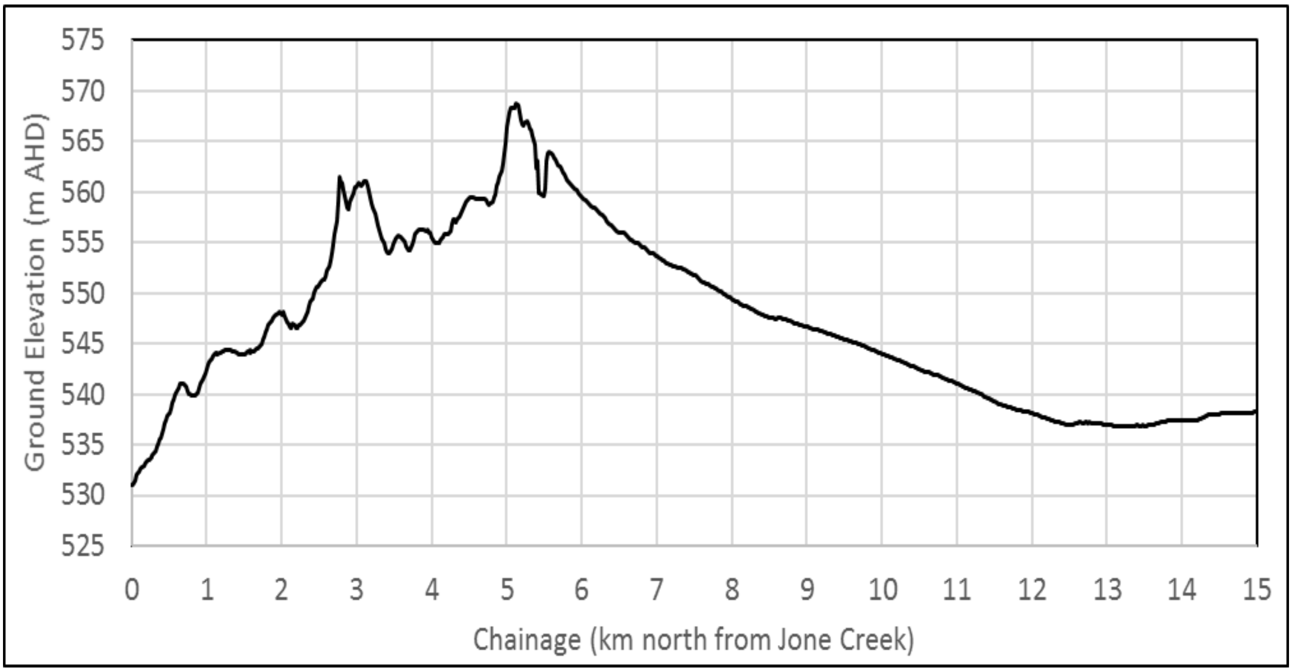

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Figure 57 Haul Road Route Surface Profile

From Jones Creek the general route features and gradients are as follows:

- 0-1.2 km: Ascend directly, traverse at high level, cross ridge line and exit Jones Creek catchment. Route gradient up to 2% and mostly low transverse gradients.
- 1.2-6.4 km: Oblique ascent / high level traverse in east- draining catchment, crossing one lateral spur several minor drainage lines, then the route enters the flatter Mt Keith catchment. The route gradient is mostly less than 2%. There are short steeper sections of 4-8% gradient within chainage ranges 2.7 - 2.9 km (crossing the spur) and 4.9 - 5.6 km (ascending the minor breakaway). Lateral gradients 0-2% to the east.
- 6.4-15 km: Gradual decent of the south slope of the Mt Keith valley, route turning from direct descent to oblique descent to valley floor traverse. No incised channel drainage features. Route-line gradients less than 1% and lateral gradient to the east at less than 0.5%.

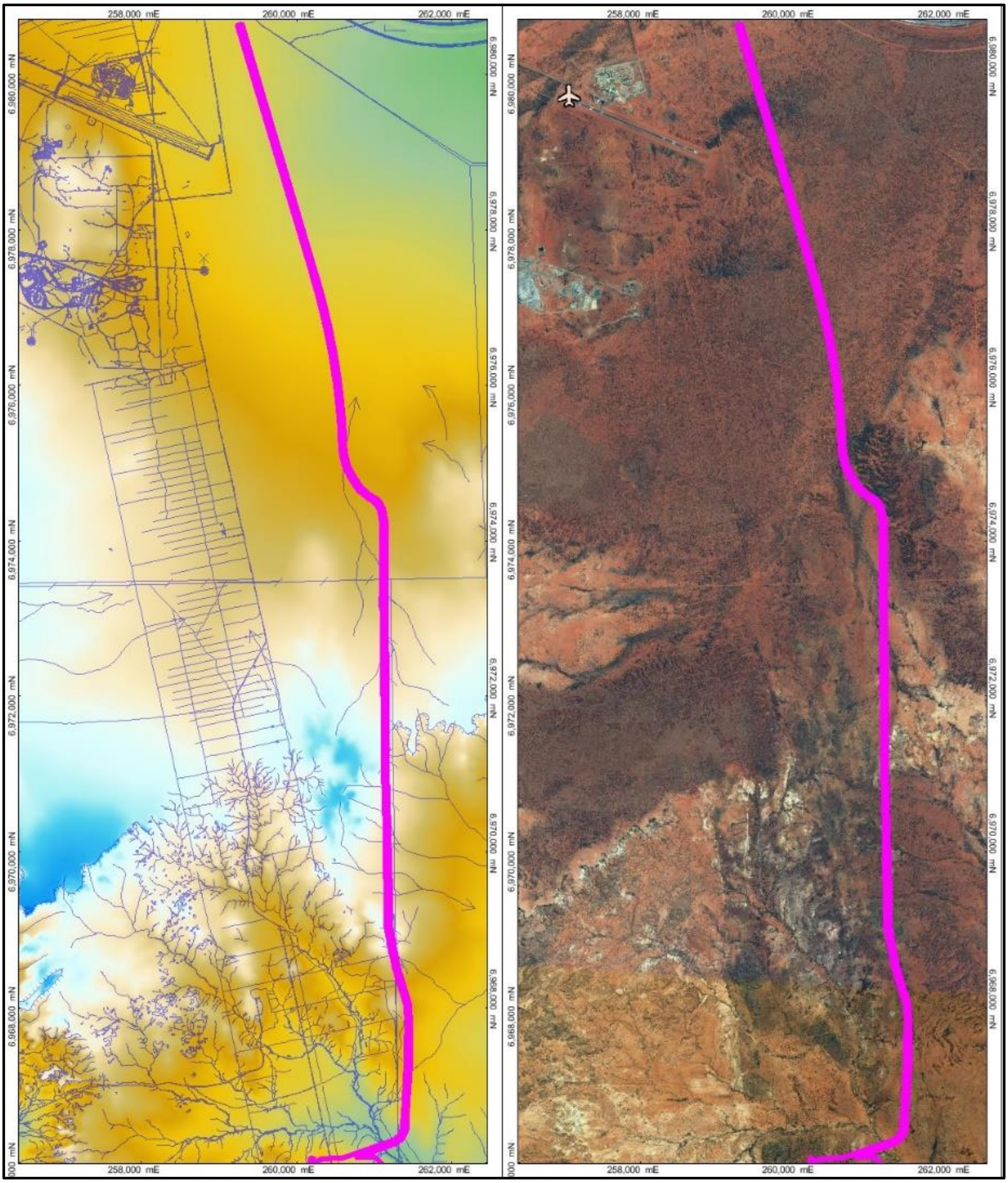

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Figure 58 Mt Keith Haul Road Route and catchment drainage

Specific drainage features are summarised in Table 43.

Table 43 Specific drainage features on the haul route

East	North	Chainage (m north from Jones Creek)	Feature	Catchment		
				Area (km^2)	Slope, (m/km)	Peak flow (100 year) (m^3/sec)
261180	6969460	3440	Creek	0.135	14	1.3
261170	6969720	3710	Creek	0.376	14	3
261170	6970130	4100	Minor Cr	No incised channel		
261160	6970250	4240	Minor Cr	No incised channel		
261160	6970470	4450	Minor Cr	No incised channel		
261150	6970820	4810	Creek	0.161	34	2.2
261130	6972460	6460	Swale	No incised channel		
261130	6972840	6840	Broad Swale	No incised channel		
261130	6973280	7290	Flood-out	No incised channel		
260610	6975100	9310	Flood-out	No incised channel		

In general, the route poses relatively minor drainage challenges and the potential impacts are mitigated by the following factors:

- surface gradients are low to very low;
- drainage lines are only slightly incised and have small catchment areas; and
- vegetation density is generally moderately low.

The haul road design base case is for a low crown profile with finished road surface close to the natural ground surface. This will minimise environment impact, drainage structures and fill volumes. The design uses floodways to convey stormwater at the crossings listed in Table 43 above.

Groundwater drawdown

A groundwater flow model APAC (described in MWES, 2017b) was developed to evaluate the pumping requirements and the extent of drawdown of the Six Mile Well pit and is based on that developed and calibrated for the existing Mt Keith pit for geotechnical purposes. The model set up is discussed at length in MWES Consulting (2017b) (Appendix N), with the findings presented below.

Figure 59 shows a stylised representation of the cross-section through the Six Mile Well pit including the pre-development water levels and maximum drawdown induced by dewatering as simulated by the flow modelling. Figure 60 shows the simulated extent of drawdown after four years of mine dewatering as the 5m and 2m drawdown contours, and the aquifer submergence values.

Dewatering is achieved with abstraction at an average rate of 14 L/sec over 4 years. The 5 metre drawdown cone is predicted to extend 500-700 metres from the pit crest along strike and 300-500 metres across strike. Comparing the drawdown cone to the aquifer submergence (Figure 53) it is clear that the extent of partial aquifer dewatering is less extensive than the 5 metre drawdown cone – i.e. submergence of less than 5 metres is limited to the extent of the dunite ultramafic which is fully enclosed by the 5 metre contour.

Aquifer dewatering is limited to the area where the drawdown exceeds the pre-development submergence – i.e. where the aquifer becomes unconfined. The extent of any partial aquifer dewatering is less than the extent of the 5-metre drawdown contour. In the baseline condition minor aquifers are typically submerged (confined) by 20m such that, at maximum Proposal drawdown, they will remain fully saturated, and practically unimpacted, well within the 5m drawdown contour extent.

In summary, the dunite aquifer will be largely depleted by dewatering, however the array of minor aquifers in the surrounding country rock will mostly remain fully saturated and hence environmental values will be largely unaffected in these minor aquifers. The rock types and general geological characteristics of the greenstone belt and hence the hydrogeological regime hosting the array of minor aquifers is continuous for many kilometres to the north and south of the Proposal area.

Groundwater levels will be maintained at the base of each pit whilst there is active mining and dewatering will result in a cone of drawdown in the water table around the pits. After mining is complete, water levels will then gradually rise to equilibrium levels. The Six Mile Well pit will be completely backfilled such that the long term equilibrium water levels will return close to the baseline condition. The post-closure Goliath pit will remain a permanent void. The resulting residual impacts are as follows:

- Operational drawdown from the Six Mile Well pit will be comparable to the Mt Keith pit, extending of order 100's of metres beyond the pit crest.
- After closure and back-filling the drawdown cone will gradually refill.
- There is potential for changed water quality in the backfill and for movement of the impacted water laterally away from the backfilled pit (though-flow) (discussed further in Section 9).
- There are no aquifers at the Goliath Pit, drawdown extent will be limited. Dry conditions and absence of any pathway or receptor for groundwater impacts negates the requirement of drawdown modelling.
- A lake will develop at the base of the Goliath void.

Given water table depths of 15 to 35m, it is considered that surface vegetation is not groundwater dependent. Development of an ecohydrological conceptual model for Jones Creek in the upper catchment proximal to the propose Six Mile Well and Goliath pits, taking into account a high-level system water balance, determined the risk of impacts to tree health caused by drawdown in the vicinity of the proposed mine pits is negligible (Appendix O). Mature Eucalypts in Jones Creek adjacent to the Six Mile Well Pit and other vegetation are not considered vulnerable to drawdown impacts since the baseline water levels are normally at least 15m below the creek bed level and pit dewatering will not affect soil/rock moisture in the overlying profile.

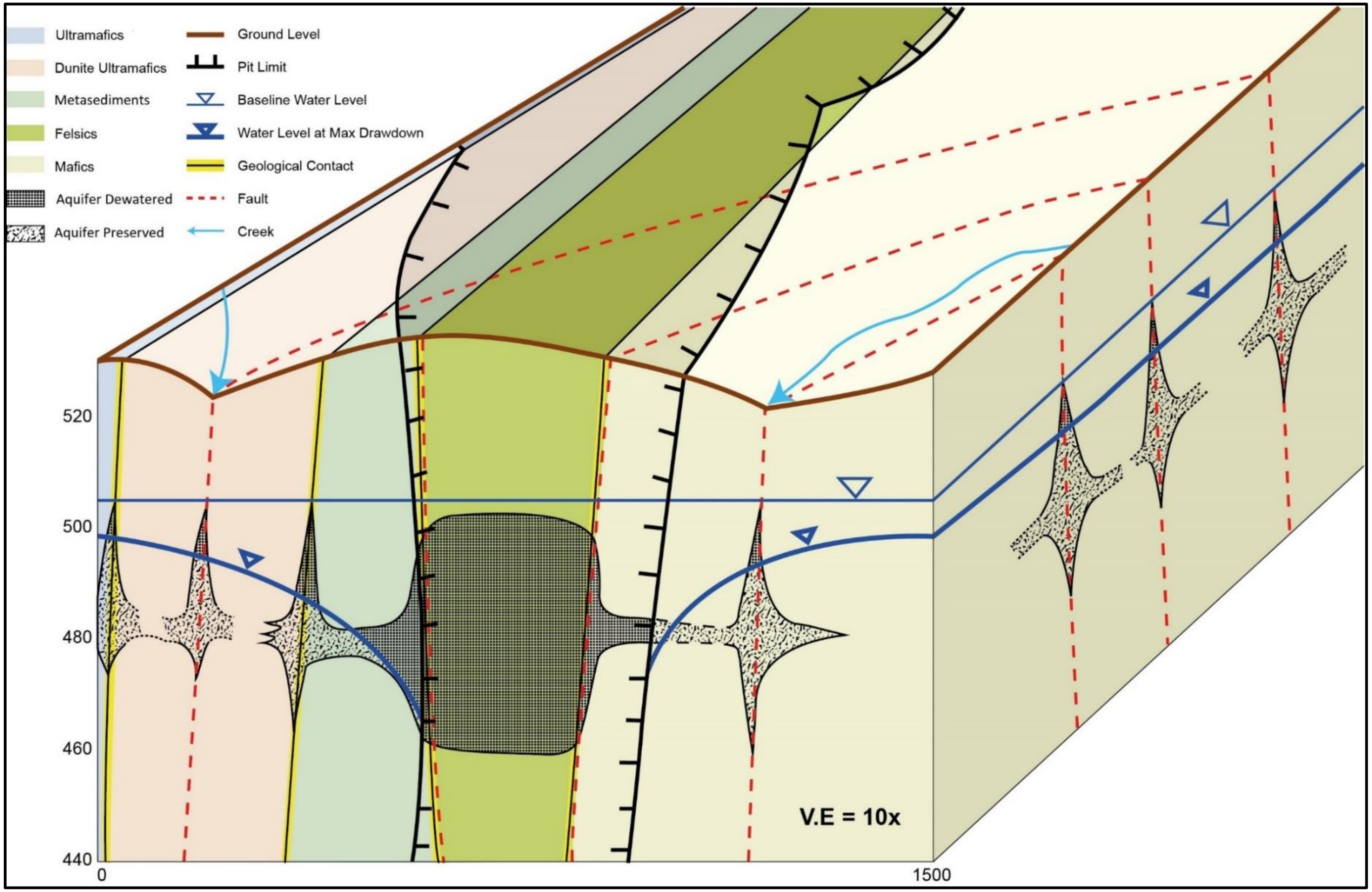
As discussed in Section 7, two stygofauna species have been recorded from within the modelled Six Mile Well groundwater drawdown impact areas. Both species are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The drawdown is therefore not likely to pose a long term conservation risk to these species.

Proposal water supply

NMK's current operations include a largely integrated water supply network including stormwater harvesting and groundwater abstraction from existing borefields and operational dewatering bores at Mount Keith and Cliffs. All groundwater abstraction for supply is licensed under RIWI Act licences issued by DWER and DWER approved Operating Strategy (Nickel West, March 2016). The existing operation has five Groundwater Well Licences (GWL's) for a total allocation of 18 GL/a (570 L/sec) and typical annual use is 11 GL (350L/sec). The existing sources are shown in Table 44.

Table 44 Mt Keith Water Supply

Water supply	Groundwater Licence	Licensed allocation (Gl/yr)	Water Quality	Abstraction rate L/sec
Albion Downs Borefield	GWL69507	10.95	saline	260
Caprock Borefield	GLW50299	1.5	sub-potable	50
South Lake Way Borefield	GWL60382	3.285		
The Village Borefield	GWL		sub-potable	15
Mt Keith Pit Dewatering	GWL58596	2	saline	15
Cliffs Nickel Mine	GWL173900	0.5	-	10
Stormwater harvesting	-	-	Highly variable supply	10



MWES Consulting, 2017b

Figure 59 Hydrogeological setting and dewatering drawdown effect

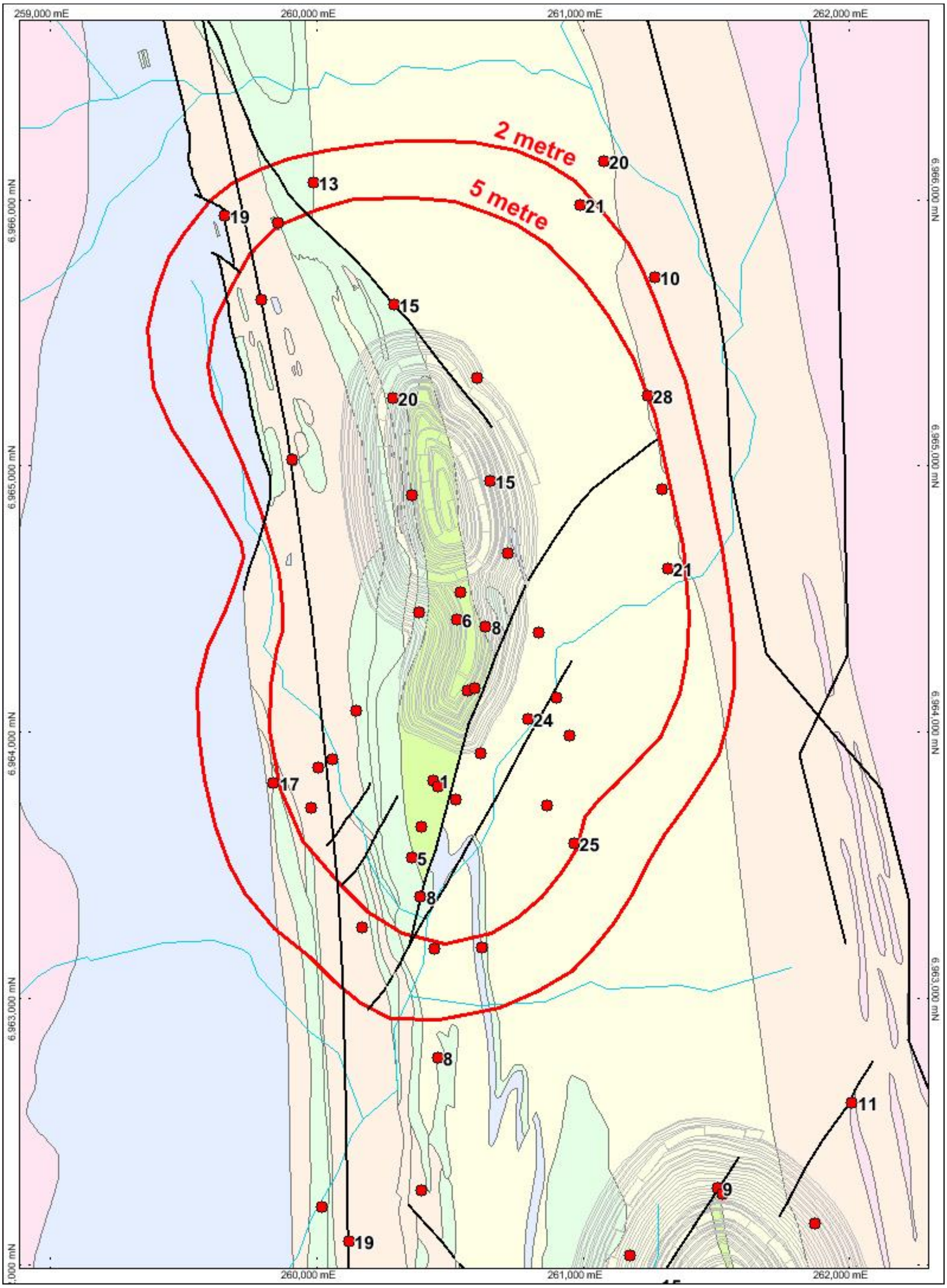


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Figure 60 Groundwater model simulated dewatering drawdown and baseline aquifer submergence

There will be no change to the current water management circuit in operation at Mt Keith, where the various bore-fields automatically feed into different parts of the process and are supplemented with return water, harvested stormwater and dewatering discharge from Cliffs Nickel Mine. Water for the Proposal will be drawn from existing take-off points within the Mt Keith water circuit, for example: the raw water dam, and piped to site within the haul route corridor.

NiW has submitted a revised Operating Strategy for Yakabindie GWL 63902 which will regulate dewatering from Six Mile Well and Goliath pits. The document reflects the current Mt Keith practices and specifies an annual abstraction limit of 1095 ML or an average of 35 L/sec. The total includes allowances for groundwater and for stormwater.

The site water balance for the Proposal has been estimated from historical Mt Keith pit usage, based on dry weather demand, as follows:

Local haul road dust suppression	15 L/sec
ROM dust suppression	5 L/sec
Drilling	2 L/sec
Mt Keith Road dust suppression	20 L/sec
Ancillary	3 L/sec
TOTAL	50 L/sec

These are typical dry weather requirements when dust suppression water trucks are operating at normal capacity. Annual averages will be lower, with lower use during occasional rainy periods.

The net increase in demand to the existing integrated Mt Keith water balance requirement is 20 L/sec, as the only additional demand component is the “Mt Keith Road dust suppression”. All other components are simply relocated from the existing Mt Keith Pit to the Satellite Pits. The net increase is partly offset by additional local supplies from the Proposal.

Groundwater modelling indicates that dewatering of the Six Mile Well pit will generate a yield of 15 L/sec for about 4 years after which the yield is expected to drop to about 10 L/sec. The Goliath Pit is expected to yield small quantities of groundwater which will not materially impact the dry weather water balance. The higher yield from the Six Mile Well pit will be obtained during the first 3 years of the mine schedule, i.e. during Goliath Stage 1.

The dry weather supply deficit for the stand-alone Proposal water balance will initially be 35 L/sec and will increase to 40 L/sec after about 4 years. From an integrated Mt Keith perspective, the water balance deficit is offset by reduction in water use at the Mt Keith Pit as the resource declines, such that the net deficit is 5-10 L/sec. In the context of the existing Mt Keith water balance, the Proposal represents a moderate change due to relocation in mining, and a very small increase in overall requirements. Overall, the viability of continuation of existing water supply sources is required for 15 years, that is, 5 years for the existing Mt Keith pit source and 10 years for the Proposal.

Make-up water supply options include:

- Cliffs dewatering excess of 20L/sec of which approximately 10L/sec is used to make up Mt Keith pit supply, however the surplus is currently discharged to the CDTSF. Whilst this excess is partially recovered by decant to the Mt Keith concentrator, this source is favourable for redirection as supply to the Proposal.
- Yakabindie borefield (or Southern Borefield) located 20km south-southeast of the Proposal site, which is licensed by NiW (GWL 63896) for 1.5 GL/annum (48 L/sec) but currently managed via a sublease arrangement to a third party. Once the Proposal commences, this arrangement will be reviewed to determine if water allocation is required for overall Operations water supply.
- Mt Keith Concentrator supply – the Proposal represents a 10 year continuation of the current water demand situation. However as Mt Keith resources expires, the water supply for the pits will not be required for mining and provides a minor net positive to the water supply.

- Caprock borefield (7 production bores) has typically supplied 40% of sub-potable requirements and about 6% of total groundwater supplied to operations. This borefield is a collection of small isolated aquifers with drawdown localised by their limited geological extent and low yield. Three of these bores are located in northern palaeochannel, exploiting a more robust aquifer than the four southern ultramafic rock hosted Caprock bores. Since a very small portion of the palaeochannel has been developed for groundwater usage, it can be expected that any localised depletion will be ameliorated by flow along the channel from undeveloped areas, i.e. the limited extent of development of the aquifer means that severe or extensive depletion is not possible. On this basis, historical rates of supply from the borefield can be sustained for the life of the Proposal, subject to RIWI Act licensing (the current licence is for supply of up to 1.5 GL/annum until 2022).

- South Lake Way borefield has three independent components described below. On the basis of the following discussion, the historical rates of supply can be sustained for several decades, subject to RIWI Act licensing (the current licence is for supply of up to 3.285 GL/annum until 2022).

- SLW16 and SLW17: located west of the CDTSF are low yielding bores tapping relatively isolated fractured rock. Similar to southern Caprock bores these are operated at high drawdown with pumping water levels near or within the aquifer zone to maximise yield from surrounding rock. There is little potential for extensive drawdown impact and the historical rates of abstraction should be sustainable indefinitely.

- SLW02, SLW03 and SLW04: Located east of the TSF these bores tap alluvial aquifers. Water levels are stable or rising indicating that TSF seepage and rainfall recharge are volumetrically dominant over groundwater abstraction. Maintaining the current rates of abstraction should be possible.

- SLW07, SLW08 and SLW09: The eastern bores are located where the palaeochannel and shallow alluvial sedimentary basin is thicker and broader. The main reservoir is the shallow alluvium. The aquifer response is well defined by the average drawdown in regional monitor bores in a similar manner to the Albion Downs borefield, however drawdown at South Lake Way is very much less than at Albion Downs. Abstraction of 8.6 GL from 1994 to June 2013 had induced a drawdown of 2.4m and the long term drawdown trend was 0.21 m/GL. The required yield from the area of about 0.5 GL/a will produce a drawdown rate of about 0.1m per year which means that the bores can maintain current supply rates for at least several more decades.

- Village borefield (7 production bores) located within 3kms of the Mt Keith Village. This borefield supplies near-potable quality water to the Village where it is treated by reverse osmosis for potable supply. The bores draw water from minor and relatively isolated fractured ultramafic and granitoid hosted aquifers. As is common for fractured rock aquifers, the bores are operated with relatively high drawdown - i.e. with pumping water levels below the top of the aquifer zone. This allows a maximum amount of leakage to the aquifer zone from surrounding low permeability bedrock. Since the yield is naturally limited by the rate of seepage from surrounding country rock into the fracture system tapped by the bore, there is no potential for long term depletion and current supplies should be available indefinitely, subject to RIWI Act licensing (the current licence is for supply of up to 275 ML/annum until 2022).

- The Albion Downs Borefield comprises 32 production bores located at about 1/5km intervals along the axis of a major regional palaeochannel aquifer. This borefield produces about 80% of the water supplied to Mt Keith. Long term monitoring has shown a steady and predictable rate of drawdown. This response is typical of groundwater abstraction from storage in a bounded aquifer system. The steady rate of drawdown over periods of substantial variation in rainfall, indicates that rainfall recharge to the groundwater aquifer is a very small component of groundwater abstraction.

Based on long term average process water requirement of 0.81 kL/tonne of ore processed, the development will require a total of 80 GL from the Albion Downs Borefield. From measured abstraction of 169 GL to June 2015, the total abstraction will rise to about 210 GL by the commencement of satellite pit ore in early FY21 and to 290 GL by the end of the mine life in FY31. The long term drawdown rate of 0.04 m/GL indicates that average regional upper aquifer drawdown will increase from 8.5 m in 2015 to 10.2 m in FY21 and to 13.4m by 2031.

The prognosis for borefield operation and impacts from the extended borefield life is not substantially changed from MWES Consulting’s most recent aquifer review. Basin delineation drilling at the time of the borefield development showed that the typical saturated thickness of the upper aquifer was 15-20 metres. The residual saturated thickness of 7-12 metres (2015 water levels) will allow ongoing supply from the existing borefield at current rates to 2031. Additional water storage in the aquitard, lower aquifer and surrounding host rocks will provide further capacity although possibly at diminishing rates. Ongoing localised trends of rising salinity are likely to continue as brackish-saline water in the upper aquifer is further depleted and saline-hypersaline water from the lower aquifer dominates the overall supply. The impacts on the salinity increases on the quality of the aggregate supply are moderated by the fact that many of the bores already deliver water of stable hypersaline quality.

In summary, there is sufficient capacity within NiW's borefields to provide for the proposed water balance deficit of 5 to 10L/sec, which takes into consideration the offset by reduction in water use at Mt Keith pit as the resource is depleted.

Groundwater Mounding

Groundwater mounding is caused by local recharge to the saturated zone in an unconfined aquifer, and is more likely to occur in areas with a shallow groundwater table. This increase in the water table may cause inundation of root systems of adjacent vegetation and associated vegetation death. A change in water quality from recharge may also impact on stygofauna habitat.

In the context of mining, mounding may be caused by surplus dewater injection or seepage from pit lakes and tailings storage facilities. Management of seepage at NMK is not addressed in this assessment as this is managed under separate approvals and closure planning.

No surplus water will be generated from the Proposal and therefore dewater injection is not a consideration for this assessment. As discussed above, there will be a slight water deficit that will need to be met by existing water supply options.

The Six Mile Well dunite ultramafic is an unconfined or semi-confined aquifer. Upon completion of mining, the Six Mile Well pit will be backfilled and will not be subject to evaporation losses such that groundwater levels will recover, at least to the baseline water table level (503m AHD).

The final steady-state water level is dependent of the rate of groundwater recharge. The recharge rate through the fill is dependent on run-off and vegetation interception of the final cover. Recharge rates have been estimated based on the assumption of a moderately compacted and gently mounded surface and a low scrub/grass vegetation cover being gradually re-established. Initial recharge rates will be very much higher than baseline conditions, rates will decline as surficial fines are rearranged and vegetation is established but will remain very much greater than baseline conditions (less than 10 mm/year). The assumed recharge rate is 35 mm /annum (15% of rainfall) declining to 12 mm/annum (5% of rainfall) after 20 years. The early value affects the rate of water level recovery and the later value the final steady rate water level or degree of mounding and additional groundwater through-flow away from the site. Based on modelling, the assumed long term recharge rate (5%) results in steady state water level of 0.6m above background water level.

Locally the aquifer at Six Mile Well constitutes the most extensive aquifer, but at a regional scale is a considered a small and localised caprock aquifer. Permeability and porosity diminishes with depth and degree of weathering below the aquifer zone. The predicted rise in water table of 0.6m above background and potential flow through away from the pit, is not considered significant in terms of water volume or quality.

The post closure Goliath pit will remain a permanent void. After completion of mining to the pit floor at 80m AHD, the water level will gradually stabilise at less than 140m AHD, leaving a small pit lake with a water level more than 300m below the pit crest. This will form a minor discharge zone from the generally impermeable country rock. Short term fluctuations relating to the most extreme rainfall events will result in relatively minor variations from the long term water level trend line, having a magnitude of no more than 2m and duration of several months. Given that no extensive aquifer has been found associated with the Goliath ore body, the risk of groundwater mounding is negligible.

8.5 Mitigation, Residual Impacts and Outcomes

A summary of the key mitigation measures to address potential impacts to hydrological processes are listed in Table 45. This includes consideration of mitigation strategies required to manage inherent impacts and residual impacts after the application of these measures. These strategies are addressed in a Hydrological Processes

Management Plan (Appendix D) which describes the monitoring and adaptive management program to ensure that residual impacts are not greater than predicted. Monitoring and management actions associated with Closure are addressed in the Mine Closure Plan (Appendix E).

The Significant Residual Impact Model as detailed in the WA Environmental Offsets Guidelines (2014) has been applied to the Proposal, as detailed in Table 67.

Table 45 Environmental Management of Hydrological Processes

EPA Objective	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.	
Inherent Impacts Requiring Management	**Mitigation Strategies**	**Outcomes**
Reduced catchment flow and yield within Jones Creek due to creek crossings, retention of stormwater in pit voids and dumps and capture of creek flow by the pit voids. Shadowing effects of haul road, i.e. intercepting water that would otherwise have drained away, primarily as sheet flow Six Mile Well pit drawdown impacts on subterranean fauna	**Avoid** • The Six Mile Well pit footprint has been designed such that Jones creek diversion is not required. • Proposed mine layout is designed to lie outside of the flood zones. • Jones Creek crossings constructed to avoid impact to surface flows. **Minimise** • Design of single large waste rock landform minimises footprint and impact on catchment. • Construction of clean water diversion drains impose volumetric limits on stormwater by the disturbed area, and maintains catchment flow. • Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. • Peak flood flow exclusion bund constructed at pit perimeter. • Undertake monitoring of groundwater levels in the vicinity of Six Mile Well pit to confirm predicted extent of drawdown cone from dewatering and recovery of groundwater levels following completion of mining. • Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline. • Limit groundwater abstraction for Proposal water supply to pit dewatering, and existing NMK water supply (borefields and stormwater harvesting). • Road design for haul route to include the following control measures: • Breakaways - Grading exposes clay saprolite which may be to prone to erosion. Competent rock cladding of erosive material (clay saprolite) exposed in cuttings and in table drains on steeper sections, particularly within breakaways. • Long slope-parallel sections - Erosion in the lateral table drain. Adequately close spacing of diversion drains. • Oblique floodway crossings - Roadway capturing drainage. Additional sub-basecourse fill to raise the road profile on the down-slope size of the floodway. • Contour-parallel sections - Vegetation "shadowing". Eliminate windrows in areas where overland flow needs to be maintained including swales, floodways (specific drainage features) and other areas where vegetation appears to be enhanced by overland flow perpendicular to the roadway. • Undertake monitoring and adaptive management in accordance with the Hydrological Processes Environmental Management Plan (Appendix D). **Rehabilitate**	**Residual Impact** The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. For the large majority of creek flow events, there is no potential interaction between the flood water and proposed major landforms (pits and dump). The potential for interaction only occurs in small areas at the margins of extreme flood levels which will occur briefly (less than one hour) and rarely (less than once in 50 years). A small amount of permanent bunding will securely isolate the Six Mile Well pit void from high-stage creek flow. The small incursions of the WRL onto the Jones Creek extreme flood zone are in areas of low stream velocity. Modelling has determined that catchment scale reduction in flow volume to be minor. Flow frequency and duration will be practically unaffected and total catchment discharge reduction will be approximately proportional to the catchment area reduction. Modelling shows that in most years that large scale catchment-wide flow occurs, the total annual yield greatly exceeds the capacity of the terminal Claypan such that the frequency of filling the Claypan will be barely diminished by the development. Road alignments have been adjusted to minimise impacts where possible and are not problematic from a hydrological perspective. Surface gradients along and across the proposed routes are generally low. Some relatively minor drainage measures, cut slope cladding and road surface profile modifications cladding are detailed. Groundwater modelling shows that drawdown of 5 metres will extend up to several hundred metres beyond the pit crest. In the baseline condition minor aquifers are typically submerged (confined) by 20 metres such that, at maximum Proposal drawdown, they will remain fully saturated, and hence practically unimpacted, well within the 5-metre drawdown contour extent. Surface vegetation is not considered to be groundwater dependent due to depth to water table and will not be affected by either dewatering of post-closure potential rise in water table of 0.6m above baseline. Groundwater mounding is not considered to be a significant residual impact. The two stygofauna species found within the drawdown impact zone are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable

EPA Objective	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.	
Inherent Impacts Requiring Management	**Mitigation Strategies**	**Outcomes**
	• Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). In particular, backfilling of the Six Mile Well Pit will allow full recovery of groundwater levels.	portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The drawdown is not likely to pose a long term conservation risk to these species. **Offsets** Based on the assessment that the development of Proposal infrastructure and associated dewatering will not pose a long term risk to local and regional hydrology, no offsets are proposed.

9 Inland Waters Environmental Quality

9.1 EPA objective, policies and guidelines

The EPA's objective inland waters environmental quality is:

> "to maintain the quality of groundwater and surface water so that environmental values are protected."

Inland waters environmental quality is defined by the EPA, for the purposes of EIA, as "*the chemical, physical, biological and aesthetic characteristics of inland waters*".

Inland waters includes groundwater, waterways, wetlands and estuaries. A 'waterway' is any river, creek, stream or brook, including its floodplain and estuary or inlet. This includes systems that flow permanently, for part of the year or occasionally, and parts of the waterway that have been artificially modified.

The focus of this factor and objective is:

- how the discharge of waste is minimised; and
- how any discharge of waste or use of land or water will significantly impact on water quality and the environmental values it supports.

The policy and guidance documents considered in the environmental impact assessment for this factor are listed in Table 46. The ERD is consistent with these documents.

Table 46 Policy and guidance relevant to Inland Waters Environmental Quality

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Inland Water Environmental Quality (EPA, 2016).	Outlines how the EPA considers inland waters environmental quality in the EIA process, including how this factor links with other environmental factors.	The ERD describes potential impacts to surface and groundwater quality that may occur through the implementation of the proposal. Appropriate mitigation measures are proposed to minimise these risks. The primary controls being stormwater diversion and separation and treatment of dirty stormwater. The ERD demonstrates that the Proposal can be implemented such that existing surface and groundwater quality can be maintained through the implementation of appropriate mitigation measures.

9.2 Receiving environment

The baseline surface hydrology and groundwater hydrogeology, including water quality is provided in Section 8, and is based on MWES Consulting (2017b) report provided in Appendix N. In addition, an aquatic ecology impact assessment of the Jones Creek system was undertaken by MWH (2016), previously Outback Ecology, and now part of Stantec, provided in Appendix R.

Regionally the Proposal Development Envelope is situated within the Lake Miranda catchment and at a local level, the upper reaches of the Jones Creek catchment. Jones Creek is an ephemeral water course, which drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to several claypans near the valley axis. The claypans are located approximately 10 km south of the Goldfields Highway. During high flow events there is high connectivity throughout the system, although water quickly recedes in the creek to remnant pools, while the claypans hold water for longer. The catchment has been subject to historic pastoralism, resulting in degradation to the riparian zone of the creek and claypans.

Generally the baseline water quality in the Jones Creek system is characterised as circumneutral to alkaline, freshwater, with low turbidity (except in the claypans), and variable nutrients. Metals (such as nickel and zinc), are typically present in low concentrations, with the exception of aluminium and copper which are known to exceed the ANZECC (2000) 80% species protection trigger values for freshwater in both the creek and claypans.

Baseline stream sediment is typically 85% sand sized particles and up to 1.2% clay sized particles. During high flow, coarse sand and gravel is mobilised within the creek, while finer suspended sediment is deposited in the claypans. Metal concentrations in the sediment are generally well-below the interim sediment quality guideline high trigger values for aquatic ecosystems ANZECC (2000). However, chromium and nickel have been recorded at concentrations between the interim sediment quality low and high trigger values.

The creek and claypans provide an important freshwater refugia within an arid environment, supporting a diverse biological assemblage. In Jones Creek, transient insect groups were a characteristic of the aquatic invertebrate fauna assemblage, due to the limited residence time of surface water, while the claypans, which hold water for longer and are highly turbid, were dominated by resident crustacean fauna.

Groundwater is relatively scarce in the Proposal area, and lies 15 to 35m below the Development Envelope. The quality ranges from brackish to saline, neutral to slightly alkaline, dissolved cadmium, chromium, lead, selenium and zinc mostly below detection limits, elevated levels of boron and slightly elevated levels of nickel and chromium concentrations associated with the Six Mile Well ultramafic and dunite respectively.

9.3 Potential Impacts

The potential impacts and risks associated with changes to surface water and groundwater quality as a result of the implementation of the Proposal, include:

- contamination of groundwater as a result of groundwater abstraction/dewatering causing oxidation of sulphides potentially present in deposits;
- reduction in surface water quality as a result potentially contaminated run-off from active mining areas, including sediment, spillage of chemicals or hydrocarbons;
- contamination of groundwater as a result of mixing with water formed in a pit lake after closure; and
- attraction of native fauna which may be harmed in accessing and/or contact with water or by attracting fauna or stock which may harm surrounding flora and vegetation (including the Violet Range PEC and Wanjarri Nature Reserve), or predators which may prey on native fauna.

The key potential impacts and risks identified to the Jones Creek system include:

- disturbance resulting in a temporary loss or shift in aquatic habitat from the two road crossings over the creek;
- sedimentation affecting water quality and aquatic biota;
- changes in surface hydrology that influence the composition of aquatic biota; and
- contamination posing a potential ecotoxicity risk to aquatic biota.

9.4 Assessment of Impacts

Potential acid formation

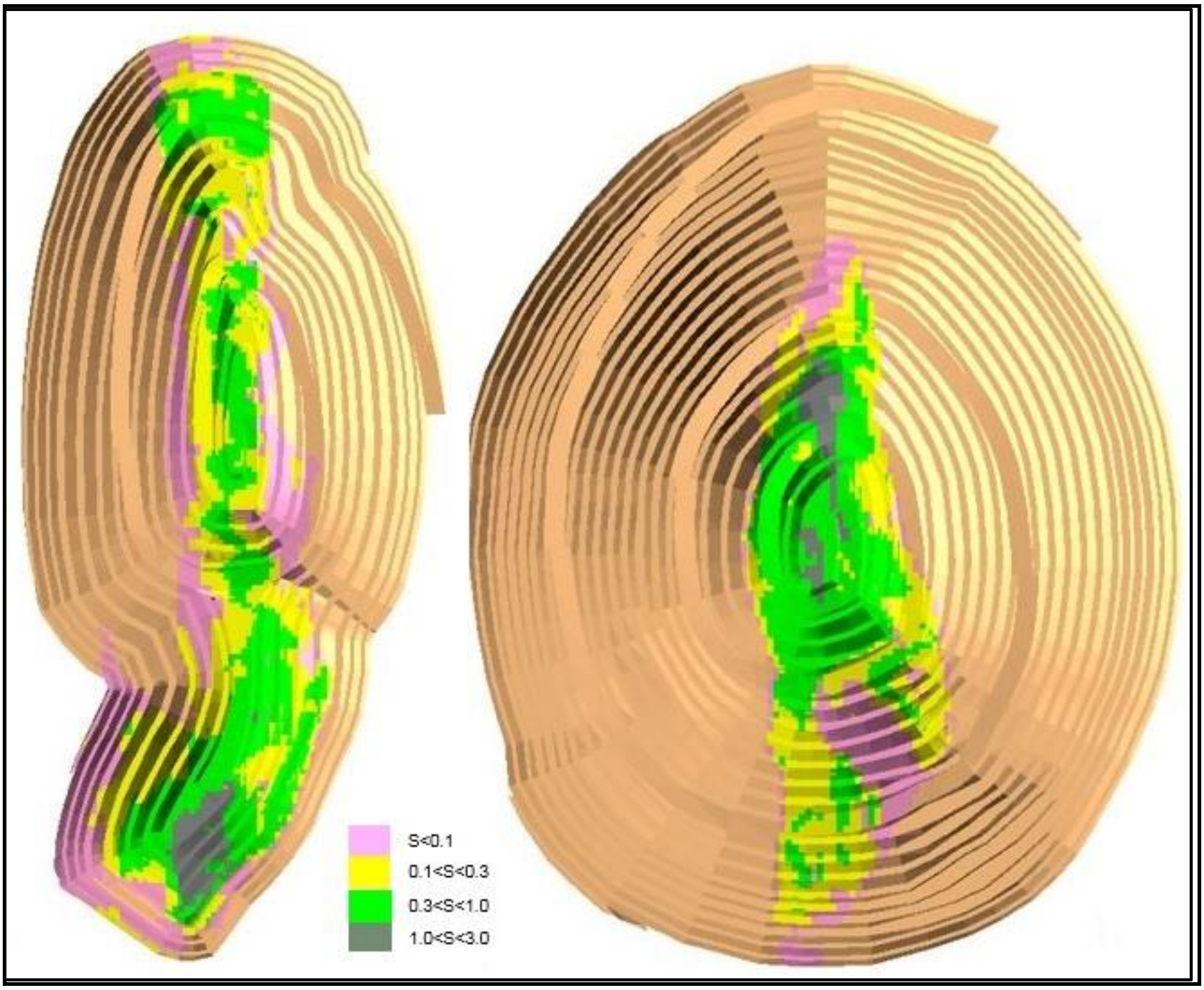
As discussed in Section 8, the waste rock generated by the Proposal is expected to contain an abundance of sulphide minerals with a moderate to high acid neutralising capacity (**ANC**). A notable exception has been identified as the volcanic sediments unit which forms a portion of the Chert/Shale, for which samples have returned total Sulphur (total-S) in the range 2-16% and despite high ANC have been classified as PAF. The sulphidic material occurs in thin bands and very low volumes in both pits. The situation is similar to the Mt Keith where large scale mining and co-disposal with high ANC material limit the potential for acid leachate at any significant scale. The waste material form existing Mt Keith operations confirmed that the majority of unweathered waste rock is competent, and does not present a risk to surface or groundwater quality. Geochemical investigations of the resources indicates the waste rock will have similar characteristics to the Mt Keith material.

The slight residual risk can of PAF material in waste rock can be controlled using the same procedures as at Mt Keith where high Sulphur material is identified initially via mine planning estimations and then confirmed during drill and blast cycles. Once identified, this can be managed during excavation and WRL emplacement.

Figure 61 shows the distribution of total sulphur (including no-reactive sulphate as well as Sulphide-S) in the walls of the final Six Mile Well Pit and the Goliath Pit shells.

Larger areas of elevated sulphur are limited to the central ultramafic unit which is exposed in the floor of the pit and in bands at the north and south ends. Routinely measurable sulphur (>0.1%) is largely absent from the larger west and east walls of the pits. At SMW higher sulphur (1-3%) occurs in the southern wall at 370-460m RL. At Goliath there is a small zone of higher (1-3%) S wall rock deep in the northern side between the 130 and 160m RL benches and the large majority of >0.3 % S wall rock below 160m RL.

The limited distribution of elevated sulphide material in the pit walls and the large proportion of high ANC for most wall rocks indicates that the risk of acidification of the SMW backfill groundwater or the Goliath pit lake is low.



MWES Consulting, 2017b

Figure 61 Total Sulphur in the Six Mile Well (left) and Goliath (right) pit shells.

Sedimentation of Jones Creek

Rainfall and surface water runoff from mining areas has the potential to increase sediment-laden water discharged to natural drainage systems, including Jones Creek. Proposal specific risks include:

- Unsuitable containment of sediment laden stormwater runoff from operational areas.
- Point source contamination from haul road creek crossings.
- Post-closure sediment load from waste rock landforms.
- Erosion and runoff form haul road
- The materials characterisation of mined ore and waste indicate these are relatively benign.

Potential pathways for sedimentation include:

- mobilisation of fine grained ore, especially from the ROM pad area into the creek line. Creek sediment has the potential to impact water chemistry in creek pools over week and months after flow events; and
- erosion and remobilisation of clay particles originating from clayey saprolite waste rock with the potential for discolouration and clogging of natural coarse creek sediments.

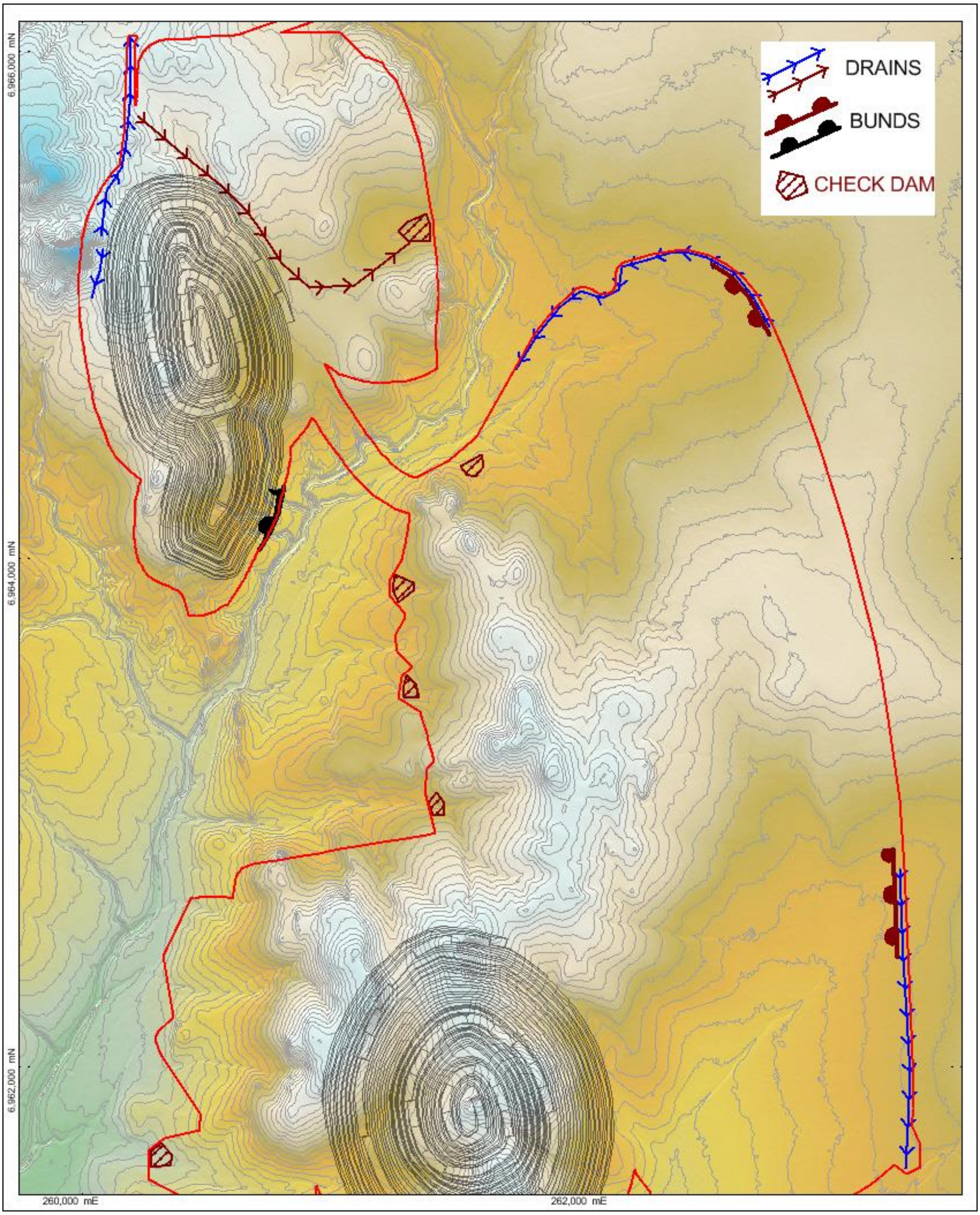
In order to mitigate these risks, “clean” stormwater needs to be diverted away from mining infrastructure, while “dirty” or sediment laden runoff is required to be separated and contained. Preliminary stormwater control structures are shown in Figure 62 and described further in**Error! Reference source not found.** Silt trap locations may be revised as stockpile and dump sequencing progresses. Key areas for coverage are potential high sediment source areas, including steep concentrated flow paths form areas where oxide material will be stored and exposed continuously over periods of months to years.

Based on effective management practices at Mt Keith with similar materials, potential erosion of clayey saprolite material within the waste rock landform can be managed by encapsulation within competent rock. Considering the low proportion of clayey saprolite in the waste and that it is encountered early in each of the three mining stages, encapsulation can be successfully implemented to manage the materials.

There is an overlap of the extreme flood area within the waste dump landform near the northeast corner of the landform. The coarse dump toe is set back 100m from the Disturbance Footprint for the waste dump landform to allow for push-down to final closure landform and a buffer zone. The risk of erosion from the WRL is mitigated by consideration of the following within the WRL design:

- maximise the distance between the flood incursion zone on the WRL from the creek main channel;
- reduce stream flow velocities experienced at the margins of the WRL to low to moderation (<0.5 m/sec);
- location of WRL where inundation will occur rarely and for brief periods; and
- coarse rock armour placement on the exposed toe segment (500m) to a height which exceeds the 100 year peak flood level (529m AHD).

The potential for sediment loading is minimal following construction and maintenance of the diversion drains, dirty stormwater capture and sediment basin interceptors.



MWES Consulting, 2017b

Figure 62 Major stormwater control structures

Surface water contamination – chemicals and hydrocarbons

The quality of surface waters may be reduced by spillage of chemicals or hydrocarbons, particularly associated with refuelling. This is not expected to be a significant risk due to the proposed installation of appropriate refuelling, hydrocarbon and chemical containment and storage facilities (e.g. self-bunded tanks). In addition, these ancillary facilities will be located in an area with appropriate stormwater diversion and capture facilities as described above.

Pit Lakes

Upon completion of mining the Six Mile Well pit will be backfilled and groundwater levels are expected to recover to at least baseline water levels after about 50 years. Water levels will then continue to rise and slightly exceed baseline levels (due to increased recharge through the backfill), with a predicted steady state level of 0.6m above background, over about 100 years and long term water quality is expected to be slightly improved. Groundwater is the volumetrically dominant source of water which will re-fill the void, so that void water quality groundwater will reflect the quality of natural groundwater. A very gradual reduction in salinity will occur due to enhanced rainfall recharge through the back-fill.

The water table of the aquifer intersected by the Six Mile Well pit, is approximately 15m below the creek bed at the closest point. Given the predicted final water level and the depth to water table in the Six Mile Pit relative to Jones Creek, impacts on creek water quality as a result of pit lake formation are considered negligible.

After closure, the Goliath pit will partially refill to form a very deep pit lake and minor discharge zone from the generally impermeable country rock. Lake water will initially reflect the chemistry of groundwater, being brackish and with low levels of trace components except for slightly elevated boron. Evaporation is the dominant process in controlling changes in water quality and will causing a continuous long term increase in the concentrations of all dissolved constituents and notably increased salinity. The pit lake will likely have elevated solute concentrations of metalloids, metals and salinity as a result of neutralised acid mine drainage and evapo-concentration.

The pit lake has a terminal nature for hydrology with a high freeboard mitigating decant risk. As a result there is no significant pathway for groundwater or surface water discharge from the pit.

A source-pathway-receptor (SPR) environmental risk assessment was undertaken (Appendix P) which assessed the risk of impacts to birdlife by direct dermal toxicity and indirect biomagnification toxicity. The risk assessment considered inherent and residual risks in a simple and spatio-temporal context and is detailed in Figure 63.

The risk assessment determined that:

- the pit lakes ecology fails to provide convincing transport mechanisms that would constitute a contaminant pathway from pit lake water to bird life, and
- the pit lake does not constitute a significant contaminant pathway risk as habitat use by birdlife.

Selenium is not present in unusual concentrations in the host rock, nor is it enriched by the nickel mineralisation. The limits of reporting (0.01 mg/L) in baseline Selenium analysis aligns with the Australian Drinking Water Guideline (NHMRC Ver 2.0 Updated December 2013), however it is noted that Selenium concentrations at 0.01 mg/L represent an elevated concentration. After closure, concentrations in groundwater will gradually increase through evaporative concentration in the pit lake, however selenium will not become a significant component of the overall toxicity of the water. Ongoing monitoring of pit lake water quality post closure is not proposed due to lack of significant contaminant pathways to fauna and groundwater.

Register #	Category	Item		Likelihood	Consequence	Simple risk	Extent	Duration	Spatio-temporal risk
1	ADM pit lake water quality	Direct dermal toxicity to birdlife	Inherent	2 Water birds may drink from and use pit lake surface as habitat e.g., as a predator avoidance strategy.	2 COPCs at low concentrations.	**4**	1 Localised to pit lake only with no contaminant transport pathway away from site.	5 CPOCs will remain elevated in perpetuity.	**20**
			Residual	1 Depauperate aquatic food sources, littoral riparian margin and terrestrial vegetation provide little birdlife habitat. Birdlife pit lake use low as few habitat requirements met there.	1 COPCs at low concentrations and mitigated by extremely high water hardness. Increasing salinity renders pit lake water undrinkable to wildlife in a short-term.	**1**	1 Localised to pit lake only with no contaminant transport pathway away from site.	5 CPOCs will remain elevated in perpetuity.	**5**
2		Indirect biomagnification toxicity to birdlife	Inherent	1 Birdlife may use pit lake ecosystem for food resources.	2 Birdlife may feed on aquatic biota; including adult life stages of aquatic juveniles that have developed in the pit lake. Bioaccumulation in these biota may lead to biomagnification of some COPCs; especially heavy metals.	**2**	1 Localised to pit lake only with no contaminant transport pathway away from site. Food feed unlikely to influence large region due to limited primary production.	4 CPOCs will remain elevated in perpetuity.	**8**
			Residual	1 Birdlife not expected to frequent or reside over significant periods of their lifespan or for significant life stages e.g., breeding on and immediately around the pit lake.	1 Dystrophic pit lake aquatic ecosystem provides poor food source diversity and biomass.	**1**	1 Localised to pit lake only with no contaminant transport pathway away from site. Food feed unlikely to influence large region due to limited primary production.	5 CPOCs will remain elevated in perpetuity.	**5**

Figure 63 Pit lake risk assessment

There is a risk that pit lakes may attract native fauna or stock. This may result in harm to fauna accessing the pit or through contact with the water and potential increase in predators. Increased access of stock has the potential to increase pressure on native vegetation surrounding the pit. The likelihood of access to the water is low due to the inherent depth to water and if access were possible, studies undertaken for the Mt Keith Closure Plan (Nickel West, 2017) indicate that once the pit lake water becomes hypersaline, fauna will not drink the water. This risk will be mitigated by the construction of an abandonment bund and perimeter stock fencing around the final void. Other controls will include construction of bund across the top of pit access ramps to deter stock (cattle), fauna and human access (in the event abandonment bunds and fences are breached) and diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks.

Aquatic Biota

A baseline aquatic biology and water quality study was undertaken by Wetland Research and Management (2005, Appendix Q). An aquatic ecology impact assessment was completed for the Proposal, to identify threatening processes and the likelihood and risk of these impacts to the Jones Creek system (MWH 2016), which is presented in Appendix R. The risk to aquatic biota, which are highly adapted to their temporary environments, is assessed to be minor to negligible, and the closest feature of the Proposal (Six Mile Well Pit) is approximately 50m from the creek.

Potential impacts are either considered to be a minor, temporary disturbance within the context of the scale of the creekline and distance of the terminal claypan, or are unlikely to occur, due to expected mitigation and management measures, minimising the risk to aquatic biota. While two new, verified aquatic invertebrates have been recorded from the creek and claypans, these taxa are unlikely to have a restricted distribution (with high connectivity throughout the area during flood), or be impacted by the Proposal. However, any potential impacts are expected to be managed via appropriate engineering and design, as well as the implementation of the Hydrological Process Environmental Management Plan (Appendix N).

The creek floods irregularly, for short periods, with remnant surface water pools remaining, which provide freshwater habitat for aquatic biota. The pools typically persist for less than two months after a major rainfall event, and are characterised by a comparable, mobile biological assemblage along the length of the creek. Therefore disturbance associated with construction of the two road crossings for the Proposal is expected to be minor and temporary, with suitable engineering and design to maintain flow. Potential sedimentation issues are also expected to be negated via engineering design and construction, with the installation of bunds, silt traps and clean stormwater diversion drains expected to minimise potential impacts to the creek.

Changes to surface hydrology from the Proposal estimate that the most obvious change may be to the primary terminal claypan, with a potential reduction in median total flow (<15%). However, the claypan already receives more water than its current storage capacity, and the hydroperiod has been extended due to historic catchment clearing and pastoralism. This will likely negate any reduction in flow and minimise potential impacts to aquatic biota during flood events.

The low grade nickel sulphide ore, and low solubility of minor elements during weathering, suggests potential contamination, particularly from nickel, is unlikely. There is also a degree of natural mineralisation within the catchment, reflected in the comparatively higher concentrations of some metals in groundwater, surface water and sediment. However, these are background levels, and are often a characteristic of waterbodies in the Goldfields region, with aquatic biota inhabiting these environments having evolved to cope with these conditions. In addition, any potential runoff of contaminants and associated exposure periods are most likely to occur during major rainfall events, with dilution and dispersal reducing potential ecotoxicity impacts on aquatic biota. Potential point sources of contamination such as hydrocarbon spills are also expected to be minimised through appropriate protocols and management for the Proposal.

9.5 Mitigation, Residual Impacts and Outcomes

A summary of the key mitigation measures to address potential impacts to surface and groundwater quality are listed in Table 47. This includes consideration of mitigation strategies required to manage inherent impacts and residual impacts after the application of these measures.

The Significant Residual Impact Model as detailed in the WA Environmental Offsets Guidelines (2014) has been applied to the Proposal, as detailed in Table 67.

Table 47 Environmental Management of Inland Water Environmental Quality

EPA Objective	**To maintain the quality of groundwater and surface water so that environmental values are protected.**	**Outcomes**
Inherent Impacts Requiring Management	**Mitigation Strategies**	
Sedimentation of Jones Creek due to contaminated stormwater runoff from mining areas. Sedimentation of drainage lines due to erosions of haul road. Contamination of surface water by hydrocarbons and chemicals. Oxidation of sulphidic ore causing acidic drainage. Seepage of water from pit lakes to local groundwater post closure. Stock and/or native fauna access to pit lakes and risks to animals as well as increased grazing/ trampling pressure on surrounding vegetation. Disturbance resulting in a temporary loss or shift in aquatic habitat from the two creek crossings	**Avoid** • Landforms designed to lie outside of flood impact zones. • Haul route directly departs from the Jones Creek catchment. • With the exception of the road crossings, the nearest Proposal feature is approximately 50m from Jones Creek. **Minimise** • Disturbance to aquatic habitat and riparian vegetation within Jones Creek limited to construction of the two road crossings, which will maintain flow. • Construction of stormwater diversion drains to reduce volume of stormwater over disturbed areas, reducing potential sedimentation and contamination of the creek. • Construction of dirty water capture drains to capture stormwater from disturbed areas to silt traps, preventing sedimentation and contamination of the creek. • Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. • Construction of clay bunds to prevent stormwater flow and contamination down creek lines blocked by the WRL. • Coarse dumping of non-erodible/competent rock on the outer surface of the WRL. • Peak flood flow exclusion bund constructed at south east pit perimeter of Six Mile Well pit. • Divert dirty stormwater to silt traps and first flush check dams. • Silt traps, check dams to be unlined to provide first flush storage capacity with overflow for ongoing runoff and designed to contain volume of 4mm runoff depth across sub-catchment. • Rock cladding of erosion prone slopes graded for haul road construction (breakaways and creek crossings). • Coarse rock armour of the exposed toe segment (500m) to a height which exceeds the 100 year peak flood level. • Identification of PAF waste during drill and blast cycles and encapsulation within a designated cell in the WRL. • Self-bunded fuel and chemical storage facilities. • Undertake monitoring of groundwater quality in the vicinity of Six Mile Well pit. • Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline conditions (Appendix R). • Post closure construction of abandonment bund and perimeter stock fencing around the final Goliath pit void and construction of bund across the top of pit access ramps and suitable egress point for fauna and stock (in the event abandonment bunds and fences are breached). • Post closure diversion of diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks. • Undertake monitoring and adaptive management in accordance with the Hydrological Processes Environmental Management Plan (Appendix D), which incorporates an ecological monitoring program for Jones Creek.	**Residual Impact** The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. Segregation of clean and dirty stormwater is the primary mitigation measure to protect local surface water quality. Stormwater diversion away from mining infrastructure and capture and treatment of contaminated stormwater will be implemented. Potential acid forming material will be encapsulated with high acid neutralizing capacity within the WRL. Seepage from the backfilled Six Mile Well pit and the Goliath pit lake to groundwater will be minor and of similar quality to existing groundwater. It is not anticipated that the pit lake will increase fauna or stock activity in the area, as access will be prevented by bunding and fencing. The residual impacts of the Proposal on surface water, sediment, groundwater quality and ecology are not considered to be significant and can be managed through the implementation of the proposed mitigation measures. **Offsets** This Proposal meets the EPA's objective for the inland waters environmental quality factor, with residual impacts not considered significant. No offsets are proposed for this environmental factor.

EPA Objective	To maintain the quality of groundwater and surface water so that environmental values are protected.	Outcomes
Inherent Impacts Requiring Management	**Mitigation Strategies**	
Sedimentation affecting water quality and aquatic biota Changes in surface hydrology that influence the composition of aquatic biota Contamination posing a potential ecotoxicity risk to aquatic biota	**Rehabilitate** • Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	

10 Social Surroundings

10.1 EPA objective, policies and guidelines

The EPA's objective for social surroundings is:

> *"to protect social surroundings from significant harm".*

Based on the definition of social surroundings in the EP Act, for it to be considered in EIA, there must be a clear link between the Proposal's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings.

The policy and guidance documents considered in the environmental impact assessment for this factor are listed in Table 48. The ERD is consistent with these documents.

Table 48 Policy and guidance relevant to Social Surroundings

Policy and Guidelines	Key Aspects	Application
EPA Policy and Guidelines		
Environmental Factor Guideline – Social Surroundings (EPA, 2016).	Outlines how the EPA considers social surroundings in the EIA process, including how this factor links with other environmental factors.	The ERD has considered the impact of the Proposal on the social surroundings of the area, with respect to: • visual and recreational amenity values of the Wanjarri Nature Reserve; • matters of Aboriginal heritage and cultural associations and traditions; and • hydrological processes within Jones Creek. The ERD demonstrates that there will be some residual impacts despite best efforts to avoid or minimise impacts, namely: • Varying levels of visibility of the final waste rock landform on route to Wanjarri Nature Reserve; • Twenty four places listed on the Register which are likely to occur within the Development Envelope, may be impacted by the Proposal in whole or part; and • Two creek crossings required for Jones Creek. However the potential impacts can be managed by implementation of appropriate mitigation measures, including avoidance through site design where possible, clearing limited to Development Envelope and implementation of management measures to control noise and dust. NiW believes that the residual impacts are not significant and the EPA objective for social surroundings can be met for this Proposal.
Other Policy and Guidelines		
Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004).	Provides guidance for consideration of Aboriginal heritage in circumstances where the heritage values are linked directly to the physical and biological attributes of the environment and when the protection and management of those attributes are threatened as a result of a proposed development.	The ERD considers Aboriginal heritage as it is linked to the physical and biological attributes of the local environment and the potential impacts of the Proposal on these values. Key areas of Indigenous cultural and social significance are: • The Barr-Smith Range; and • Jones Creek. The mythological narrative is associated with the range area of the Barr-Smith Range. The Proposal will not directly impact the range area of the Barr-Smith Range. Direct impacts on Jones Creek (Ngulu Wuri Wuri) by the Proposal will be limited to two creek crossing locations. The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. This will be managed through ongoing engagement with the Tjiwarl.

Policy and Guidelines	Key Aspects	Application
Aboriginal Heritage – Due Diligence Guidelines Version 3.0 (DAA and DPC, 2013).	These guidelines assist land users to understand and meet their obligations under the AH Act.	Twenty four places listed on the Register which are likely to occur within the Development Envelope, may be impacted by the Proposal in whole or part. Most of these are within the area of the existing s 18 consent approvals under the AH Act. Some restrictions to access for traditional and cultural purposes including hunting and gathering will be required during the construction and operation of the mine. However, the development of the CHMP for the proposed operations will detail land access protocols for traditional owners and serve to strengthen and extend the cultural and heritage links with the area. Establishing these links will enable both parties to respect and consider approaches to mitigate impacts to the tangible and intangible heritage of the Development Envelope. NiW considers that the EPA objective for social surroundings as it relates to Aboriginal heritage and culture, can be met.

10.2 Receiving environment

The Proposal lies within the eastern portion of the Murchison Biogeographic Region and the East Murchison subregion, which is characterised by internal drainage; extensive areas of elevated red desert sand plains with minimal dune development; salt lake systems associated with occluded Palaeodrainage system; and broad plains of red-brown soils and granitic breakaway complexes as well as red sand plains (Cowan, 2001). The vegetation in this region is dominated by Mulga varieties (*Acacia aneura* sens. lat. And related taxa), shrublands / woodlands often rich in ephemeral species, Spinifex (*Triodia* spp.), hummock grasslands, Saltbush shrublands (*Atriplex* spp.) and Samphire (*Tecticornia* spp.) shrublands. Land use is predominantly pastoral and mining (often combined) (Cowan, 2001).

The Proposal lies to the west of the Wanjarri Nature Reserve, with the main haul road to Mt Keith abutting the western boundary of the Reserve.

Implementation of the proposal requires the clearing of up to 878 ha of native vegetation within the Disturbance Footprint, for which associated impacts on flora and vegetation and fauna are discussed in Sections 5 and 6.

The Proposal also lies within the upper catchment of Jones Creek, an ephemeral water course which drains the largest catchment of the Barr-Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to a claypan near the valley axis. Implementation of the Proposal will require the construction of two creek crossings to facilitate movement of material between the pits, WRL, ROM and the existing Mt Keith Mine and concentrator.

10.3 Potential impacts

In the context of the definition of social surroundings, the key social surroundings elements and key impacts under assessment for the Proposal are:

- alterations to hydrological processes associated with Jones Creek;
- impacts on Aboriginal heritage and cultural associations with the area; and
- impacts on amenity values of Wanjarri Nature Reserve.

The hydrological impacts of the Proposal with respect to Jones Creek and its catchment are discussed in Section 8.

Potential impacts on Aboriginal Heritage and amenity values of Wanjarri Nature Reserve are assessed below.

10.4 Existing environment – Aboriginal heritage and cultural values

The Federal Court has found that the Tjiwarl People (**Tjiwarl**) are the common law holders of native title (as traditional owners) to an area which includes the Development Envelope of the Proposal, and a wider area (*Narrier v State of Western Australia* [2016] FCA 1519).

The Tjiwarl consist of multiple family groups. Over time (pre and post determination), NiW (and predecessor companies) have consulted with members of these family groups regarding Aboriginal heritage and cultural values in and around the Development Envelope. These consultations have included the engagement of Tjiwarl family groups as well as other Aboriginal people with cultural knowledge of the Development Envelope in heritage surveys.

This broad consultation has resulted in the collection of a large amount of information about Aboriginal heritage and cultural values for the Development Envelope including about dreaming mythologies such as the joint mythology of the Tjinkunya (Dragon Fly) and Tjila (Carpet Snake) Dreaming (the Tjinkunya Tjila Dreaming). A range of different views have been expressed over time about the cultural heritage values of the Development Envelope including but not limited to ethnographic Aboriginal sites (as defined by the *Aboriginal Heritage Act 1972* (**AH Act**)).

Key areas of Indigenous cultural and social significance are:

- the Barr-Smith Range; and
- Jones Creek.

These areas, and places associated with them are significant to members of the Tjiwarl People.

The mythological narrative is associated with the range area of the Barr-Smith Range[1]. The Proposal will not directly impact the range area of the Barr-Smith Range.

Direct impacts on Jones Creek (Ngulu Wuri Wuri) by the Proposal will be limited to two creek crossing locations. No other part of Jones Creek will be directly impacted by this Proposal. These crossings have been designed to:

- minimise impact on flow through of the Creek;
- not impact on overall catchment drainage; and
- largely preserve the integrity of the ethnographic values associated with the Creek.

NiW will continue to consult with the Tjiwarl People regarding refining the location and final design of these crossings. Some of the unnamed watercourses associated with Jones Creek will be directly impacted.

The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. It is intended that this will be managed through ongoing engagement with the Tjiwarl.

Surveys Conducted

NiW (and predecessor companies) have conducted multiple large-scale archaeological and ethnographic surveys to identify places of heritage and cultural value and/or scientific significance over the development history of the Proposal, covering the Development Envelope and its surrounds.

The surveys have identified cultural places including contained site types of mythological connection, artefact scatters and quarries. Many of the survey reports remain confidential at the request of traditional owners.

Figure 64 depicts the Development Envelope and areas containing known Aboriginal heritage sites, which may be impacted, and in many cases include a "buffer" contiguous to the specific culturally recognised site.

Figure 65 depicts the Development Envelope and the extent of the s18 consent approvals area under the AH Act.

10.5 Heritage and Cultural Values

Within the Development Envelope

Twenty-four places listed on the Department of Planning, Lands and Heritage (**DPLH**)'s Register of Aboriginal Sites (**Register**) are likely to occur within the Development Envelope and may be impacted by the Proposal, in whole or in part. Ten of these places have not been determined to meet the criteria for places that are protected by the AH

[1] Which may be distinguished from the wider area including breakaway landforms described as part of the geological description of the ranges elsewhere in this Proposal and which is traversed by the haul road section of the Proposal.

Act. These places are listed in Table 49 as "Lodged", because they have been notified to the DPLH but have not been assessed as meeting those criteria.

The information contained on the Register about the location and geographic extent of the sites referred to in it is in some cases inaccurate and/or is identified by reference to a polygon far larger than the site itself.

Moreover, ethnographic sites sometimes have a non-specific geographical nature. This may be deliberate, to obscure and protect the actual location. The recorded external polygons are often larger than the features they relate to, and therefore the external polygon for an ethnographic site may intersect the Development Envelope, but the relevant feature may not be impacted because the heritage and cultural values exist outside of the Development Envelope. The location and extent of mythological sites may also be uncertain due to variations in the mythological stories associated with those places.

NiW has undertaken extensive work to confirm whether sites listed on the Register are in fact likely to be located within the Development Envelope and then whether they are likely to be directly or indirectly impacted; given the Development Envelope is larger than the area that will actually be disturbed.

Ten of the twenty-four sites are of an archaeological nature, and a further ten sites have both an archaeological and a mythological nature. All sites of an archaeological nature have physical characteristics that can be verified. NiW has confirmed the location of those archaeological sites within the Development Envelope of the Proposal.

Fourteen sites in total have a mythological element. While the precise geographic extent of these places may not be evident on the face of the Register, the extensive due diligence conducted by NiW (including reviews of the ethnographic record) has resulted in a conclusion that these places are likely to occur at least partly within the Development Envelope and may be impacted to some extent.

The area of the Development Envelope where twenty-three of these sites are likely to occur is the subject of s 18 consents under the AH Act given to NiW (and its related entities) on 8 January 2003. These consents allow sites within the area to be disturbed for the purposes of the development, construction, operation, and maintenance of a nickel mining and processing operation, subject to conditions relating to the recording and salvage of archaeological materials associated with them.

Management of these twenty-three sites will consist of mitigation activities in accordance with the conditions stipulated by the Minister granting consent under s 18 of the AH Act and a CHMP, which NiW proposes to develop in consultation with the Tjiwarl.
Table 49 displays the Development Envelope and areas containing known Aboriginal heritage sites, which may be impacted.

Table 49 Known Aboriginal Heritage Sites within the Development Envelope

Site Name	Place Identification	Within s 18 Approvals Area	Polygon Completely/Partially within the Development Envelope	Broad Site Type	Status
Jones Creek 96/2	106	Yes*	Completely	Archaeological	Registered Site
Six Mile Well	107	Yes*	Completely	Archaeological	Registered Site
Kiti	359	Yes	Completely	Both archaeological & mythological	Registered Site
Kunia.	363	Yes	Partially	Mythological	Lodged
Yaralangkangu	366	Yes	Partially	Mythological	Lodged
Pinawanggu.	838	Yes	Completely	Both archaeological & mythological	Registered Site
Yunatarnu	840	Yes	Completely	Both archaeological & mythological	Lodged
Wanura.	849	Yes	Completely	Both archaeological & mythological	Registered Site
Purungu	861	Yes	Completely	Both archaeological & mythological	Lodged
Wintjakunan	863	Yes	Completely	Both archaeological & mythological	Lodged
Jones Creek 1992-3	1154	Yes	Completely	Archaeological	Registered Site

Site Name	Place Identification	Within s 18 Approvals Area	Polygon Completely/Partially within the Development Envelope	Broad Site Type	Status
Ngulu Wuri Wuri/Jones Creek	1252	Yes**	Partially	Both archaeological & mythological	Registered Site
Kartan Pungu	1274	Yes	Partially	Mythological	Registered Site
Partu Kutjata	1277	Yes	Partially	Both archaeological & mythological	Registered Site
Mt Falconer Site Complex	1294	No	Partially	Both archaeological & mythological	Registered Site
Jones Creek 1	1446	Yes	Completely	Archaeological	Registered Site
Jones Creek 3	1448	Yes	Completely	Archaeological	Registered Site
Jones Creek 4	1449	Yes	Completely	Archaeological	Registered Site
Field Site Nine B	18604	Yes*	Completely	Archaeological	Registered Site
Yuralangkangu	19259	Yes**	Partially	Mythological	Lodged
Mitarrka	19260	Yes	Partially	Both archaeological & mythological	Lodged
Mcfarlanes Find 01	19404	Yes	Completely	Archaeological	Lodged
Mcfarlanes Find 02	19405	Yes*	Completely	Archaeological	Lodged
Mcfarlanes Find 04	19407	Yes	Completely	Archaeological	Lodged

* Heritage sites with conditional approval requiring a qualified archaeologist to apply for a s 16 permit to conduct further recording and selective test pitting.

** Site occurs within the s 18 consents area of the Development Envelope, and within the area of the Development Envelope where there is no s 18 consents, namely the proposed haul road area.

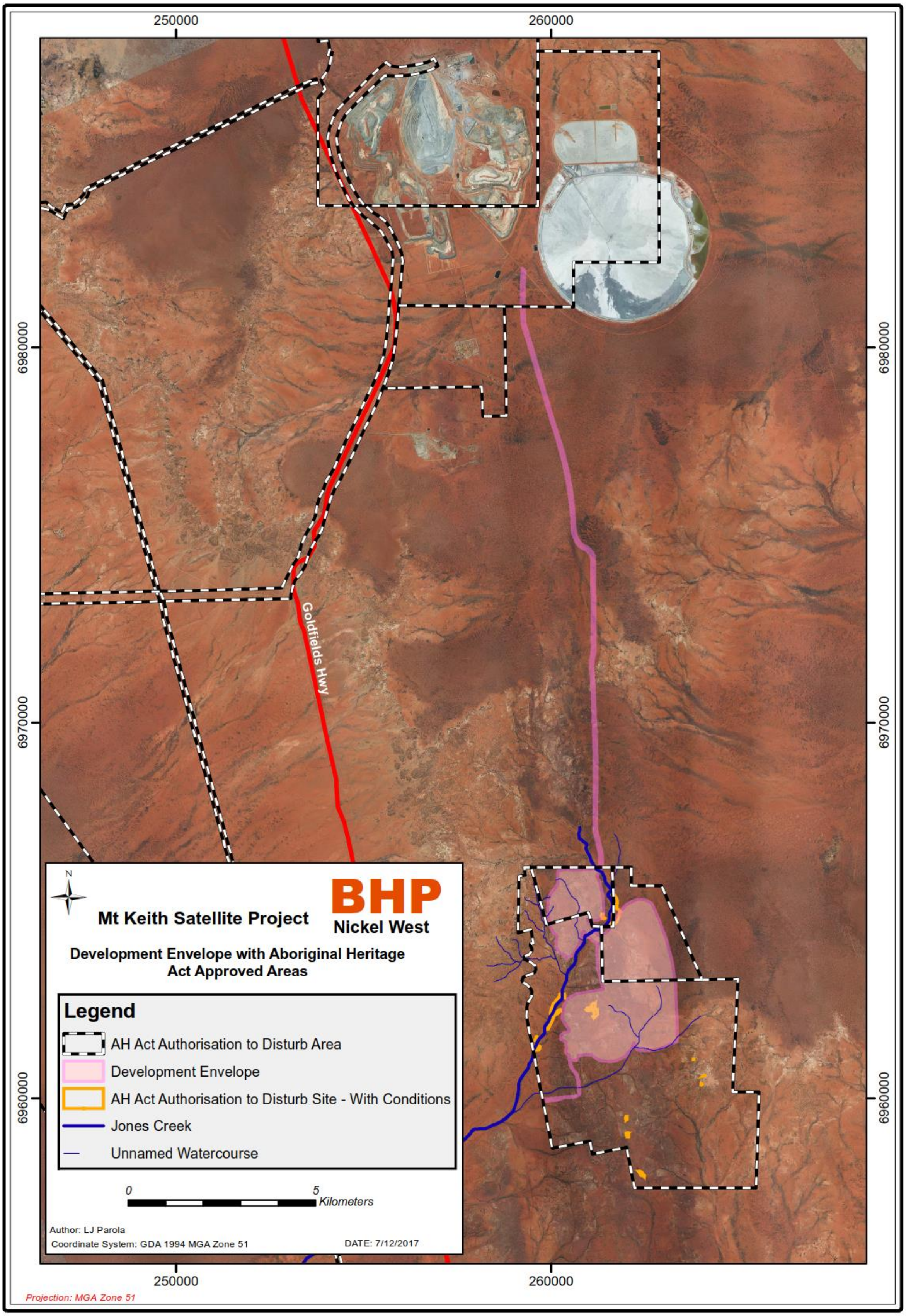


Figure 64 MKS Development Envelope and s18 consent approvals areas under the AH Act

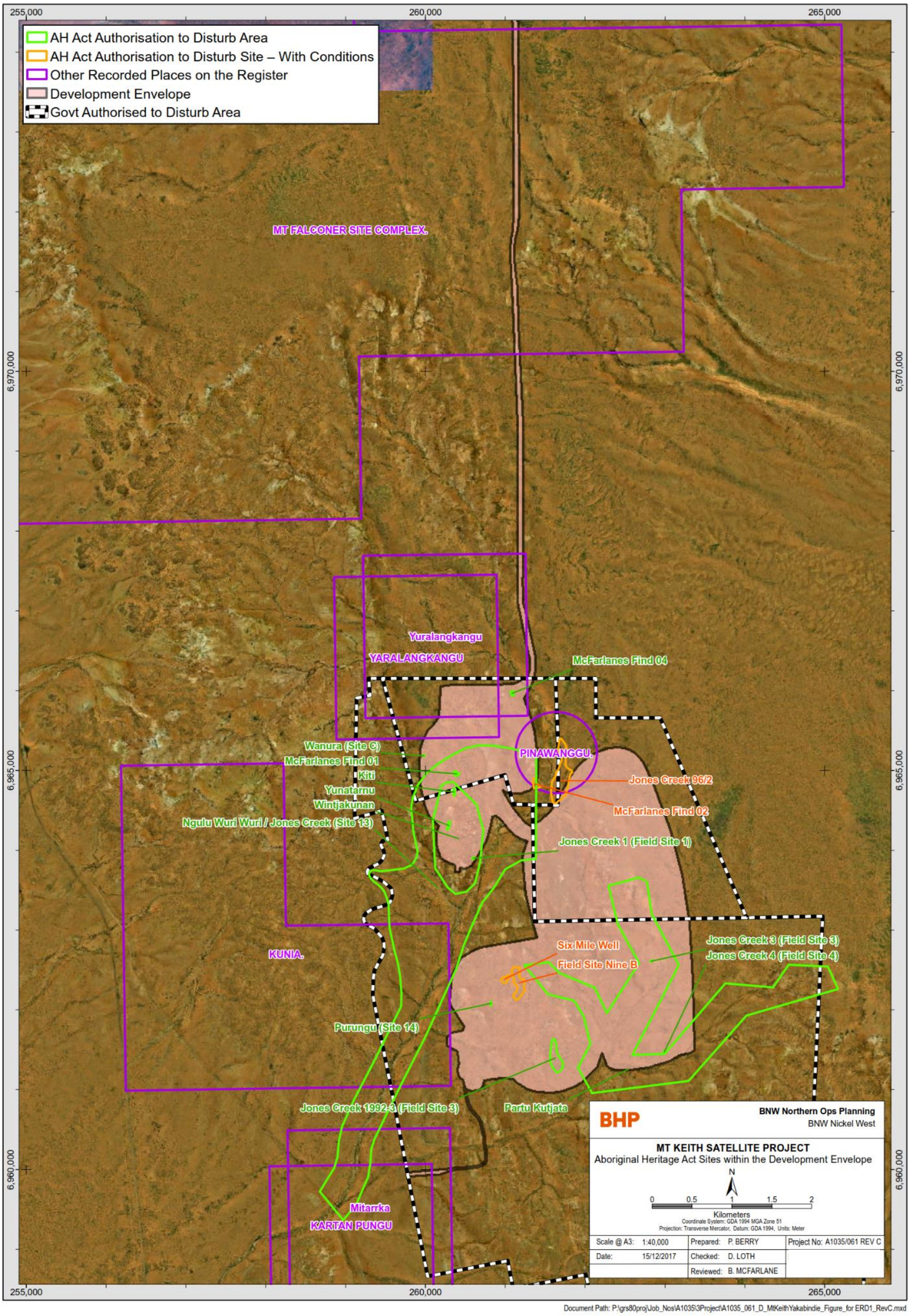


Figure 65 MKS Development Envelope and Aboriginal Heritage Sites

NiW does not currently hold any s 18 consents over the northern section of the Development Envelope covering the proposed haul road. There are two sites on the Register that may occur in this area (one of which is partially covered by the existing s 18 consents, and one site that only occurs in this section of the Development Envelope). With the assistance of the extensive surveys previously undertaken, NiW has reviewed heritage and cultural values over this area. Any impacts on heritage or cultural values will be managed through a CHMP, and if required NiW will secure s 18 consents prior to undertaking any ground disturbing activities in accordance with the AH Act.

The Development Envelope and the current s 18 consent approvals area are overlapped by polygons on the Register recorded as containing other potential Aboriginal sites. The register entries for these places include general grid references but the co-ordinates are broad, often because they are deliberately intended to obscure the actual location to protect the site or are a legacy of historic recordings on old small-scale maps. As noted above, recorded external polygons are often larger than the features they relate to, and therefore the external polygon for an ethnographic site may intersect the Development Envelope, but the relevant feature may not be impacted. The extensive surveys conducted by NiW have established that these sites are unlikely to occur within the Development Envelope, and therefore should not be directly or indirectly affected by the Proposal.

Outside the Development Envelope
Significant dreaming mythologies with the joint mythology of the Tjinkunya (Dragon Fly) and Tjila (Carpet Snake) Dreaming (the Tjinkunya Tjila Dreaming) are associated with the wider Tjiwarl native title determination area. There are mythological sites connected to this dreaming located outside of the Development Envelope, which will not be affected by the Proposal. Key sites include:

- more than 10 km from the Development Envelope - Tjiwarl (Logan Spring) and Weebo; and
- less than 10 km from the Development Envelope, but on the western side of the Barr–Smith Range, Tjulypu (Mail Change Well) and Tjinkuna.

As discussed above, other mythological sites lodged on the Register have been recorded as a general location, being a large polygon overlapping a portion of the Development Envelope. However, these are not expected to be directly or indirectly impacted by this Proposal.

10.6 Alteration of, and constraints to Aboriginal heritage and cultural values

Twenty-four recorded sites lie wholly or partly within the Development Envelope, most of which are within the area the subject to existing s 18 approvals under the AH Act.

These sites will potentially be disturbed at least in part. For some of the sites disturbed, access to them may not be possible or may be restricted (for example, for safety and operational reasons), and some aspects of the heritage and cultural values associated with these places may be impacted. In all cases where avoidance is not possible, the removal of cultural material to another location by the Tjiwarl (when requested) will ensure that heritage and cultural values, as defined by the Tjiwarl, will be preserved as far as practicable.

Some sites within the Development Envelope will be avoided and physically protected and in other cases the impact (such as to places associated with Jones Creek) will be partial and minimised. While access might be restricted to these places during some mining activities, e.g. blasting, these places are planned to be managed in accordance with a CHMP and where practicable physical access by the Tjiwarl will be maintained. The intention of this is to minimise any impact to the cultural associations of the Tjiwarl, and preserve the heritage and cultural values, to the greatest extent reasonably practicable.

In the case of archaeological sites, the scientific value and record of those places will not be lost. NiW will salvage and keep a record of the places, in accordance with s 18 conditions. Tjiwarl people will be invited to participate in that process, as part of the CHMP.

10.7 Ongoing Consultation with Traditional Owners

In 2017 NiW and the Tjiwarl have engaged on six separate occasions regarding this Proposal. These engagements generally included:

- providing a description of and answering the Tjiwarl's questions regarding the Proposal;

- discussing the heritage and cultural values within the Development Envelope and the wider area; and
- planning for and the carrying out of a site visit to the Development Envelope.
- NiW intends to work together with the Tjiwarl to manage cultural heritage within the Proposal area. To further this goal a CHMP will be developed to address:
- how any future heritage surveys, consultations and submissions are to be conducted;
- where disturbance to sites cannot be avoided, the salvage of cultural material;
- management of heritage sites including recognition, mapping and capture of places of Aboriginal heritage and cultural value; and
- preservation of cultural associations within the area generally, including but not limited to access to sites of Aboriginal heritage and cultural value.

10.8 Mitigation - Aboriginal heritage and cultural values

NiW's overall approach to manage and protect Aboriginal heritage is based on compliance with both the AH Act and the *Environmental Protection Act 1986*. This is a holistic approach to management of archaeological, ethnographic and environmental considerations.

Potential impacts to areas of Aboriginal heritage and cultural values are managed through NiW's internal Environment and Heritage Impact Approval (**EHIA**) process. This process is based on guidelines drafted by DPLH and include measures to identify significant heritage sites during planning phases to avoid or minimise potential heritage impacts.

Within surveyed areas, NiW documents the spatial location of each heritage place. All potential ground disturbing activities (e.g. clearing of vegetation, drainage work, etc.) must be approved through the EHIA process. This process requires evidence of engineering solutions to avoid heritage locations where possible. If any heritage site cannot practically be avoided, if necessary, NiW will consult with the Tjiwarl and seek consent from the Minister under s 18 of the AH Act prior to undertaking any activities that may disturb the site. Furthermore, if the EHIA process identifies insufficient information regarding potential or known heritage and cultural values, this process will trigger further study or investigation.

This process will continue throughout all phases of the Proposal life, from construction to closure activities. As part of this Proposal, a mine closure plan has been prepared (Appendix E) which provides completion criteria and closure options, supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. Throughout the operations phase, iterations of the mine closure plan will progressively refine the closure options with available data, enabling detailed designs and completion criteria to be developed and progressive rehabilitation works to occur. As part of the development of the final closure plans, the Tjiwarl will be consulted and Indigenous considerations incorporated into the plans where appropriate. For example, this may include the identification and inclusion of appropriate bush food and bush medicine plants into the rehabilitation seed mix.

As mining draws to a close, the detailed closure designs will be executed, and the site will move into the post-closure period of monitoring, reporting, completion and sign off, with the focus on achieving the defined completion criteria, following the mitigation hierarchy of control, as described below.

A summary of the key mitigation measures to address potential impacts to Aboriginal heritage and cultural associations are listed in Table 50. This includes consideration of mitigation strategies to manage inherent impacts and residual impacts after the application of these measures. Additional measures may be developed as part of the CHMP.

Table 50 Environmental Management of Aboriginal Heritage and Cultural Associations

EPA Objective	**To protect social surroundings from significant harm** **Aspect:** *Aboriginal heritage and cultural associations*	**Outcomes**
Inherent Impacts Requiring Management	**Mitigation Strategies**	
Loss/disturbance to identified and unidentified Aboriginal heritage sites Constraints on traditional cultural activities Interruption to access to the heritage sites Alterations to hydrological processes associated with Jones Creek	**Avoid** • Mine design has considered the Aboriginal heritage within the Development Envelope and has been through a substantial number of versions balancing economic and cultural concerns. • By relocating the waste rock landform, NiW has been able to avoid impacts to the Barr-Smith Range (from a mythological perspective). • With respect to Jones Creek, direct impact of the proposed Development Envelope is limited to two crossings of the creek to access the pits, WRL and ROM pad. **Minimise** • The Disturbance Footprint has been minimised by generating engineering solutions which have permitted the Proposal to remain feasible while reducing impacts on environmental and cultural values. • All ground disturbance activities will be approved through the NiW EHIA process prior to commencing. Outside of the existing s 18 approval area, if there is insufficient information regarding potential or known heritage and cultural values, this process triggers further study or investigation. • NiW intends to work together with the Tjiwal to manage cultural heritage within the Proposal area. To further this goal a CHMP will be developed and will address appropriate contingency actions. **Salvage** • Any cultural material salvaged due to a request of the traditional owners or as a condition of s 18 consents will be relocated on country or moved to a suitable cultural repository 'holding place' until such time as the material can be returned to country. • Other salvaging activities could include photographic recordings, test pitting and 3 dimensional aerial drone capture of the surrounding landscape. **Rehabilitate** • Proposal disturbance areas to be rehabilitated in accordance with the Mt Keith Satellite Proposal Mine Closure Plan (Appendix E). Refinement of the final closure plans at the end of the mine life will be undertaken in consultation with the Tjiwarl.	**Residual Impact** Despite efforts to avoid or minimise impacts on Aboriginal heritage sites, the Proposal may have a residual impact on twenty-three known places within the area for which s 18 consent was obtained in 2003. The most significant cultural heritage landscape features in the vicinity are the Barr-Smith Range and Jones Creek. The Aboriginal heritage and cultural values of the Barr-Smith Range will not be directly impacted. Jones Creek will be directly impacted at two creek crossing locations. No other part of Jones Creek will be directly impacted by this Proposal. These crossings have been designed to minimise impact on flow through of the Creek and will not impact on creek flow through and the overall catchment drainage. The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. This will be managed through ongoing engagement with the Tjiwarl. Some restrictions to access for traditional and cultural purposes including hunting and gathering will be required during the construction and operation of the mine. However, the development of the CHMP for the proposed operations will detail land access protocols for traditional owners and serve to strengthen and extend the cultural and heritage links with the area. Establishing these links will enable both parties to respect and consider approaches to mitigate impacts to the tangible and intangible heritage of the Development Envelope. NiW believes that with the proposed mitigation measures, the EPA objective for social surroundings as it relates to Aboriginal heritage can be met. **Offsets** Given the implementation of the Proposal is considered to meet the EPA objective for social surroundings as it relates to heritage, no offsets are proposed.

10.9 Existing Environment – Wanjarri Nature Reserve

As described in Section 2.4, Wanjarri Nature Reserve (**Reserve)** is an arid zone conservation reserve with high conservation values within the landforms represented and is an important area for research into the biology and habitat requirements of a range of animals, particularly birds. It is recognised that the value for nature conservation is limited by the pastoral and mining activities on land surrounding the Reserve (CALM, 1996).

Aboriginal people once used this land for hunting and gathering as well as for cultural purposes and a number of significant sites occur within the Reserve (CALM, 1996).

The Reserve was formerly a pastoral lease and still contains the original farm buildings as well as a number of relics. The Wanjarri Shearing Shed camping area is a DBCA managed campground. The aim of limiting camping to this small part of the park is to enable conservation values of the remainder of the area to be protected. The following images of Wanjarri Nature Reserve provide examples of the scenic landscape from within the reserve (Plates 3 – 6) (Goldfields Tourism, 2017).

Plate 3: Entrance to the Reserve

Plate 4: Breakaways landform

Plate 5: historic sheep yards

Plate 6: European relics

http://www.goldfieldstourism.com.au/Attractions/tabid/62/articleType/ArticleView/articleId/91/Wanjarri-Nature-Reserve.aspx (accessed: 1 December 2017)

In 2011 NiW entered into a land swap agreement with the Government of Western Australia, to excise 758 hectares of land from the class A Wanjarri Nature Reserve in exchange for 8431 ha from the Yakabindie Pastoral Lease. The land swap was undertaken to create a mining reserve for the future mining associated with the Proposal. The excision was legislated in the *Reserves (Wanjarri Nature Reserve) Act 2012.*

The excision area comprised 1.4 per cent of the total area of the Wanjarri Nature Reserve, with the inclusion area being 10 times the size of the excision area with significant conservation values.

10.10 Assessment of impacts – Wanjarri Nature Reserve

For the purpose of impact assessment, the EPA considers amenity values to include both visual amenity and the ability for people to live and recreate within their surroundings without any unreasonable interference with their health, welfare, convenience and comfort (EPA, 2016A). The key values under consideration for Wanjarri Nature Reserve that may be impacted by the development of the Proposal include visual amenity (scenic landscape and visual aesthetics) and recreational tourism.

Whilst the Proposal will not directly impact on Wanjarri Nature Reserve, indirect Proposal related risks to the values of visual amenity and recreational tourism include:

- noise, dust and light-spill emissions;
- visual impact by mining landforms; and
- changes to access to the Reserve due to mining operations.

Dust, noise, vibration and light emissions from the Proposal will be associated with blasting, heavy vehicles and machinery associated with the mining operation, which will vary in intensity and duration according to the different phases of the Proposal and the distance to sensitive receptors.

Dust (amenity)

As discussed in Section 8, NiW commissioned Ramboll Environ to undertake an air dispersion modelling study to assess the potential impacts of dust emissions associated with the Proposal on ambient air quality concentrations and dust deposition that may occur due to the mining and transport operations. The assessment focused on fugitive emissions from major dust generating activities such as drilling and blasting, mining, material handling, stockpiling, reclaiming, vehicle movements on unpaved surfaces, transport of the ore for processing and wind erosion of unpaved surfaces and stockpiles.

Air dispersion modelling (using AEROMOD) has been completed to predict short-term and long-term ambient ground level concentrations (GLCs) of total suspended particulate (TSP) (all particulate matter less than 50 µm diameter), particulate matter less than 10 µm in equivalent aerodynamic diameter (PM10) and particulate matter less than 2.5 µm in equivalent aerodynamic diameter (PM2.5), associated with a peak production scenario. The air dispersion model has also been utilised to predict particulate deposition rates of TSP in the surrounding environment and at select receptor locations.

TSP is normally associated with nuisance impacts such as dust fallout and soiling of washing. PM10 and PM2.5 are associated with potential for health impacts. Dust deposition is used to consider potential amenity impacts, such as dust depositing on fabrics and buildings.

A summary of the maximum TSP, PM10 and PM2.5 concentrations are presented in Table 51, as well as the maximum 24 hour and annual average concentrations predicted at NMK Camp and Shearing Shed Campsite. (Additional information for the seven Goldfields highway discrete locations is available in Table 5 of Appendix G).

Table 51 shows that even without any dust suppression (i.e. watering controls) employed on the transport corridor between the Proposal and NMK, predicted concentrations are below the nominated standards at all discrete receptors, including within Wanjarri Nature Reserve.

The exception, with potential for air quality amenity impact, is at the NMK accommodation camp where exceedances of the 24 hour average TSP, PM10 and PM2.5 standards and annual PM2.5 standard are predicted. Analysis of the source contributions at the NMK camp indicate that the exceedance of the PM10 and PM2.5 standards are due to emissions from haulage of the product along the transport corridor. However, when watering controls are applied to the transport corridor, the predicted concentrations at the NMK Camp are below the nominated standards as all of the discrete receptors.

Table 51 Summary of predicted TSP, PM10 and PM2.5 GLCs

Location	Predicted GLC (ug/m^3)				
	TSP[1]	PM10		PM2.5	
	Maximum 24-hour average	Maximum 24-hour average[2]	Annual Average[3]	Maximum 24-hour average[3]	Annual Average[3]
Standard	90	50	25	25	8
Scenario 1 – No controls on MKSO – NMK Transport Road					
NMK Camp	110	75	24	25	8
Shearing Shed	47	28	2	9	1
Scenario 2 - Watering on MKSO < 2 litres/m2/hour– NMK Transport Road					
NMK Camp	55	38	12	13	4
Shearing Shed	39	23	1	7	0.5
Scenario 3 - Watering on MKSO > 2 litres/m2/hour– NMK Transport Road					
NKM Camp	27	19	6	6	2
Shearing Shed	35	21	1	7	0.4

Notes:

In the absence of national ambient air quality standards for TSP, the EPA's standard for TSP within residential areas ('Area C') has been applied at sensitive receptors.
National Environment Protection (Ambient Air Quality) Measure (NEPC, 1998)
National Environment Protection (Ambient Air Quality) Measure (NEPC, 2015)

The summary of the predicted average daily and monthly deposition rates for a range of dust control scenarios is presented in Table 52.

Table 52 Summary of predicted daily average deposition at sensitive receptor locations

Location	Predicted Daily Deposition g/m2/d	Predicted Monthly Deposition g/m2/mo
Dust deposition criteria 4g/m^2/monthd[1]		
Scenario 1 – No controls on MKSO – NMK Transport Road		
Wanjarri Nature Reserve 1	0.02	0.6
Wanjarri Nature Reserve 2	0.029	0.87
Wanjarri Nature Reserve 3	0.035	1.05
Wanjarri Nature Reserve 4	0.252	7.56
Wanjarri Nature Reserve 5	0.198	5.94
Wanjarri Nature Reserve 6	0.239	7.17
Wanjarri Nature Reserve 7	0.009	0.27
Transport Corridor West	0.288	8.64
Scenario 2 - Watering on MKSO < 2 litres/m2/hour– NMK Transport Road		
Wanjarri Nature Reserve 1	0.012	0.36
Wanjarri Nature Reserve 2	0.026	0.78
Wanjarri Nature Reserve 3	0.034	0.9
Wanjarri Nature Reserve 4	0.128	3.84
Wanjarri Nature Reserve 5	0.099	2.97
Wanjarri Nature Reserve 6	0.120	3.6
Wanjarri Nature Reserve 7	0.005	0.15
Transport Corridor West	0.144	4.32
Scenario 3 - Watering on MKSO > 2 litres/m2/hour– NMK Transport Road		
Wanjarri Nature Reserve 1	0.008	0.24
Wanjarri Nature Reserve 2	0.024	0,72
Wanjarri Nature Reserve 3	0.033	0.99
Wanjarri Nature Reserve 4	0.066	1.98
Wanjarri Nature Reserve 5	0.050	1.50
Wanjarri Nature Reserve 6	0.060	1.80
Wanjarri Nature Reserve 7	0.003	0.09
Transport Corridor West	0.072	2.16

1 NSW Department of Environment and Climate Change dust deposition criteria, which is to be determined from data spanning no less than one year, so as to account for seasonal variations.

The modelling predicted the greatest impacts within Wanjarri Nature Reserve to occur at location WR4 (Figure 39) and the greatest impacts overall to occur to at Transport Corridor West receptor, which is located within 50m of the centre of the transport corridor. The prevailing winds have been analysed to be predominantly from an easterly or south-easterly direction and so the greatest depositional impacts are expected to occur on the western side of the road corridor outside of the Reserve. Within the Reserve, the risk of adverse dust impacts is considered to be low, provided adequate dust management measures are implemented, particularly on the haul road.

Dust management measures

Proposed dust management measure include the following and one or more may be implemented to reduce effects of dust from the Proposal, in particular the haul route, on the amenity of users of the Reserve (as well as within the NMK Camp):

- Wet suppression of unpaved areas using a water cart. Wet suppression of unpaved areas can achieve dust emission reductions of about 70% or more, and this can sometimes be increased up to 95% through the use of chemical stabilisation. Based on recommendations by Ramboll (2018) it is likely that the watering rate of greater than 2 litres/m2/hour in the vicinity of the camp will be required, and a lower application rate may be considered closer to the Proposal pits.
- Chemical stabilisation, such as polymer additives, may be considered for use conjunction with wet suppression, which help to form a crust on the surface and bind the dust particles together through particle agglomeration. Chemical stabilisation reduces watering requirements, but any savings are likely to be offset by the cost of the additives.
- Speed controls on vehicle movements. Speed controls on vehicles have an approximately linear effect on dust emissions. This means that a speed reduction from 30 to 15 kilometres per hour will achieve about a 50% reduction in dust emissions.
- There is no suitable control for blasting that will have a material impact on the emissions of particulates. However, scheduling of the blasting can be controlled to ensure that blasting occurs at times where meteorological conditions are such so as to minimise impacts at nearby sensitive receptor locations.

Dust modelling uncertainty

As detailed in Ramboll (2018) (Appendix G1), the prediction of ambient dust concentrations from fugitive sources using dispersion modelling is difficult due to the complexity and uncertainty in estimating dust emissions as these are affected by numerous factors, primarily associated with input data.

There are three sets of input data needed for dispersion modelling:

- source or emissions characteristics,
- meteorological data, and
- terrain and local features.

The critical factor is to know the rate of emissions, in mass units (grams per second or kilograms per hour or tonnes per day), of in this instance particulates. This needs to be known for each time period of the model run (in this instance hourly time-steps over a period of a year). Only in very special cases is this constant and known accurately. There are several possible approaches. The most common (and conservative) method, is to use the maximum emission rate, which occurs when a source is operating at its upper limit. If the emissions are measured by an 'approved' method, this is ideal.

The calculation of emission estimates for modelling associated with mining activities has been conservatively based on the maximum anticipated mining rates from proposed NiW scheduling for the Proposal. Scheduling indicates that the greatest mass of material will be handled in year 26 of the Project. The emission estimates for excavating, truck loading, stockpiling, reclaiming and waste rock dumping were therefore based on the annual throughputs for this period. This assessment has also conservatively estimated that waste rock dumping during the modelled year will occur along the eastern boundary of the waste rock landform, as this area is located most closely to sensitive receptors within the adjacent Wanjarri Nature Reserve.

If actual emissions measurements are not available, then either a manufacturer's design specification or an emission factor can be used. Given actual emissions information was not available, emissions estimates were mainly derived from emissions factors presented in the National Pollutant Inventory's (NPI) 2012 emissions estimations manuals for mining.

Most of the equations and factors presented in the NPI emissions estimation manual have been drawn from USEPA AP-42 studies, the National Energy Research, Development and Demonstration Council (NERDDC,

1988) and State Pollution Control Commission of NSW (SPCC, 1983) studies in the Hunter Valley. When information from both sources (i.e. the US and Australia) was available, the two were compared and, where possible, reconciled.

There remains some degree of uncertainty with emissions estimations, particularly wheel generated dust, blasting and wind erosion. For example, the modelling assessment predicts that one of the main sources contributing to particulate impacts is wheel generated dust from the hauling of product from the satellite operations to the Mount Keith operations for processing. The emission factor used to derive haulage related PM10 emissions was based on a silt content of 4%, where the haul roads are to be constructed with cap rock, a material associated with lower silt loadings than roads constructed with sand or gravel. The emission estimate is sensitive to the silt loading and the assumed silt loading may be conservative or could be an under estimate. There is also an assumption that the silt content of the road is constant along the entire length of the road and does not change with increased usage, material spills or maintenance of the road.

Blasting emissions were determined from the NPI emissions estimation handbook which in turn was derived from the USEPA AP-42 emission factors (USEPA, 1980). The AP-42 emissions factors state that emissions from explosives detonation are influenced by many factors such as explosive composition, product expansion, method of priming, length of charge, and confinement. These factors are difficult to measure and control in the field and are almost impossible to duplicate in a laboratory test facility. With the exception of a few studies in underground mines, most studies have been performed in laboratory test chambers that differ substantially from the actual environment. Any estimates of emissions from explosives use must be regarded as approximations that cannot be made more precise because explosives are not used in a precise, reproducible manner.

Dust emissions generated by wind are generally negligible below a wind speed threshold, but increase rapidly when wind speeds exceed the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which in turn is dependent on the size distribution of the material and whether a crust has developed. In general, material with a large (>50%) fraction of non-erodible particles (generally particles greater than 1 mm to 2 mm) will not erode as the erodible fraction is protected by these particles. Fine ores are generally much more erodible by wind erosion, particularly if they have a large fraction of particles in the range from 0.1 mm to 0.25 mm which can be dislodged by wind and then rolled and skipped along the surface (saltation). These larger particles can then dislodge the smaller (<50 µm) dust fraction which can remain suspended in the air.

The NPI Emission Estimation Technique (EET) Manual for Mining (NPI, 2011) specifies a wind erosion factor of 0.2 kg/ha/hr for all sources with the exception of coal stockpiles. However, this factor is considered approximate as it does not take into account variations in the climate of an area or the soil or ore type. Previous studies investigating the impact of dust emissions from mining facilities in the Pilbara have used the Shao (2000) equation to parameterise PM10 emissions for live stockyards and surrounding roads.

Estimates of emissions from wind erosion assume uniformity of product and therefore erodibility to the given meteorological conditions across all exposed areas and stockpiles. This assumption extends to the wind speed threshold at which wind erosion begins to occur. It would be almost impossible to accurately model the various interactions of every exposed area source within the modelling domain, and similar to wheel generated dust, generalisations are made to estimate the impact. There does exist the potential for estimated emissions from wind erosion to under or over represent actual emissions.

Lack of appropriate meteorological information can sometimes be an important limiting factor in modelling accuracy. The ideal is to have at least one year of data, with at least hourly resolution, at the site of interest (usually within a few hundred metres). The minimum measurement requirements are for wind speed and direction, but some method of estimating stability and mixing height is also required as an input for steady-state modelling. Often there are no suitable meteorological data at all. In this case, a prognostic meteorological data set can be generated and used. The use of prognostic data can assist in generating the worst-case meteorological scenarios, and show the highest concentrations that might occur, however there can be limitations in the use of this data. For example, there are known issues with using prognostic data generated by TAPM, which is known to under predict the frequency of light winds, often associated with increased concentrations from fugitive sources. DWER has previously issued guidance that the use of monitored data from larger distances is preferable to the use of prognostic data from TAPM when undertaking assessments of fugitive particulate sources (DEC, 2006).

The meteorological data used in this assessment was obtained from the nearest suitable meteorological station in Yeelirrie. Whilst this location is some distance from the satellite operations (approximately 50 km), it is thought to be indicative of regional meteorology and was therefore considered appropriate for use in the modelling assessment.

In the absence of regional background data, the modelling assessment was not able to consider the cumulative impacts of regional dust sources (such as dust storms and bushfires) in combination with the predicted ambient air quality impacts associated with the modelled sources

Noise

NiW commissioned Talis to undertake an environmental noise impact assessment for the Proposal (Appendix T). The Wanjarri Shearing Shed was identified as the nearest noise sensitive receiver (R1, Figure 66) being approximately 7km from the open cut pits and associated mining infrastructure. As the shearing shed is an official DBCA licensed camping ground, it is classed as noise sensitive premises as defined in Part 1 of the *Environmental Protection (Noise) Regulations 1997* (Noise Regulations) and is subject to the same assigned levels as residential premises. Distances to other receivers are greater than 10km.

Considering the distance of the receivers from the mining activities there are no influencing factors or penalties that are applied to the assigned levels. The applicable assigned noise levels are presented in Table 53. As the mining is a continuous operation, the noise modelling results were assessed against the L_{A10} night-time level of 35 dB (A), which is the most stringent L_{A10}.

Table 53 Noise criteria at Sensitive Receivers

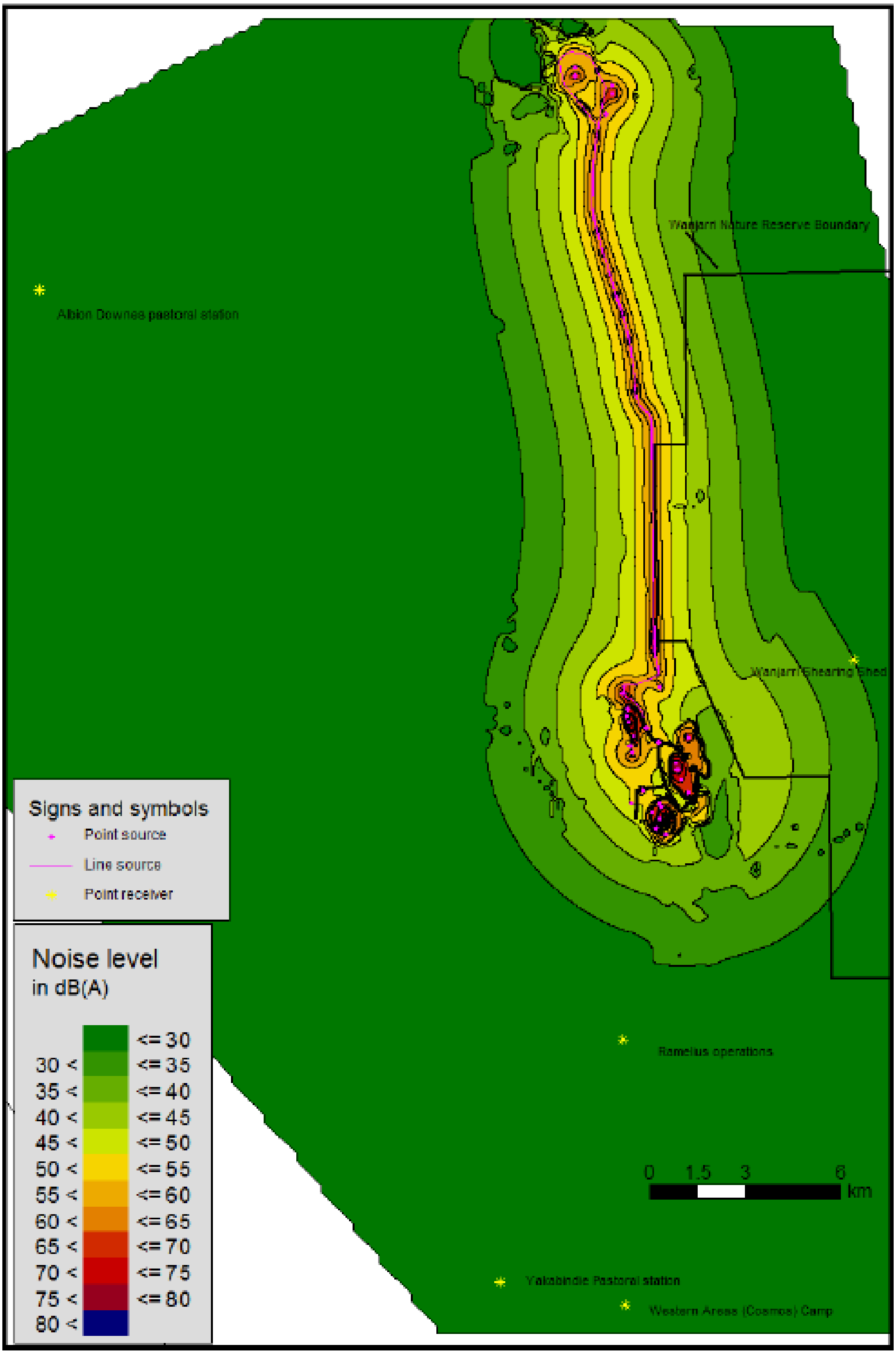
Time of Day	L_{A10} Assigned Noise Levels in dB(A)
0700 to 1900 hours Monday to Saturday	45
0900 to 1900 hours Sundays and Public Holidays	40
1900 to 2200 hours all days	40
2200 to 0700 all days	35

The predicted mining noise levels at Wanjarri Shearing Shed are shown in Table 54.

Table 54 Predicted Mining Noise Levels

Sensitive Receptor	L_{A10} Noise model prediction dB(A)	L_{A10} Assigned Noise Level dB(A)	Exceedance dB(A)
R1 – Wanjarri Shearing Shed	30.1	35	0
R2 – Albion Downs Pastoral Station	9.4		0
R3 – Romelius Operation	10.5		0
R4 – Yakabindie Pastoral Station	12.4		0
R5 – Western Areas (Cosmos) Camp	13.4		0

As can be seen from Table 54, the mining and hauling operation are predicted to comply with the assigned noise levels at all sensitive receivers. Figure 66 provides a noise contour map which indicates that noise levels along the western boundary of the Reserve range from 30 to 70 dB(A) with the highest levels being where the boundary meets the road. In terms of recreational use of the Reserve being predominantly associated with the camp ground at Wanjarri Shearing Shed, the residual noise impact is predicted to be low.



Talis, 2017

Figure 66 Predicted noise levels FY28 averaged mobile plant locations along haul road.

Talis also undertook an assessment of expected ground vibration associated with blasting operations at the Six Mile Well and Goliath pits, assuming all blasting takes place in open cut and under average conditions. Expected ground vibration levels from blasting operations at the Six-mile Well and Goliath pits were predicted using the methodology described to AS 2187.2-1993 Explosives Storage and Use- Use of Explosives and compared to the recommended levels shown in Table 55. The results determined that when blasting occurs during the day (0700-1800hrs) ground vibration levels will be within the limits specified in Table 55.

Table 55 Recommended ground vibration levels.

Description	Time of Day	Ground vibration criteria (mm/s)	
		Peak levels at any time	Limit for 9 in 10 Consecutive Blasts
Ground vibration peak particle velocity	0700-1800 (day time)	10	5
	1800-0700 (night time)	1.0	0.5

NiW will manage blasting to ensure ground-borne vibration levels are maintained below defined daytime and night time limits.

Light spill emissions

The Proposal will be operating on a 24 hour basis and lighting will be required for illumination of operational areas for safety requirements. Lighting will be used on the waste rock landform, ROM pad and pit floor (which will move to below ground surface as operations advance) and vehicle lights.

The Wanjarri Shearing Shed camping area (located within the Wanjarri Nature Reserve) was identified as a potential receptor for light spill emissions from Proposal operations (Figure 67). The Wanjarri Shearing Shed camping area is located 5.15 km from the Proposal's Waste Rock Landform and 6.0 km away from the Proposal's haul road. During night time operations, light spill emissions from the Proposal's activities may be visible (Figure 68) to temporary occupants of the Wanjarri Shearing Shed camping area.

Even though light emissions are likely to dissipate rapidly with distance from the source, the following management measures will be implemented to reduce any potential impacts of light spill from Proposal activities on the amenity values of the Wanjarri Nature Reserve, in particular the Wanjarri Shearing Shed camping area.

The management measures proposed to reduce light spill emissions from the Proposal's activities have been developed to consider the requirements of *Australian Standard AS 4282 – 1997 "Control of the Obtrusive Effects of Outdoor Lighting"* as referred to in *Environmental Protection Authority (EPA) Guidance for Planning and Development No 33, Part C, Chapter 5*:

- Proposed light spill management measure include the following and one or more may be implemented to reduce effects of light spill from Proposal activities on the Wanjarri Shearing Shed camping area.
- Road orientation – the final design of the Proposal's internal haul roads will consider the direction of the Wanjarri Shearing Shed camping area so that light spill emissions are directed away from the Wanjarri Shearing Shed camping area and not towards it;
- Lights or light equipment used on the WRL and ROM Pad will be located and orientated where they will have the least impacts of light spill emissions towards the Wanjarri Shearing Shed camping area;
- The lights or lighting equipment design used for Proposal operations will consider design features such as the installation of louvers, batters and shields to ensure that light spill emissions are focused onto operational areas and to minimise overall light spill emissions;

- If possible, lights will be mounted as high as possible to more effectively control light spill as they have a more controlled light distribution (i.e. narrower beam) and the lights will be aimed in a more downward direction, making it easier to confine the light to the Proposal's operational areas. This should reduce the overall size of potential light spill that may be seen from the Wanjarri Shearing Shed camping area.
- Lights or lighting equipment will aim lights lower, to produce a narrower beam of light, onto specific work areas where light is required to restrict light emissions of high intensities in the critical directions (i.e. away from the Wanjarri Shearing Shed camping area).
- Where possible, to keep glare to a minimum, the main beam angle of all lights directed towards the Wanjarri Shearing Shed camping area will be kept below 70° to reduce the overall effect of light spill emissions;
- Wherever possible, floodlights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit will be utilised.

Once management measures have been implemented, NiW believe that impacts from light spill emissions do not present a significant residual impact to recreational or visual amenity of Wanjarri Nature Reserve.

Visual impact

The most visible aspect of the mining operations will be the final waste rock landform with a final height of 85m above ground level (610m RL). Key visual receptors comprise visitors travelling through the area without stopping as well as those who make day trips or camp within the Reserve. A number of locations on route to, and within, Wanjarri Nature Reserve were identified for the purpose of determining visible impact of the WRL from these vantage points.

These locations are shown in Figure 68 and the details are provided in Table 56. Scaled photomontages incorporating an overlay of the final WRL landform, for each location is provided in Plates 7 to 12.

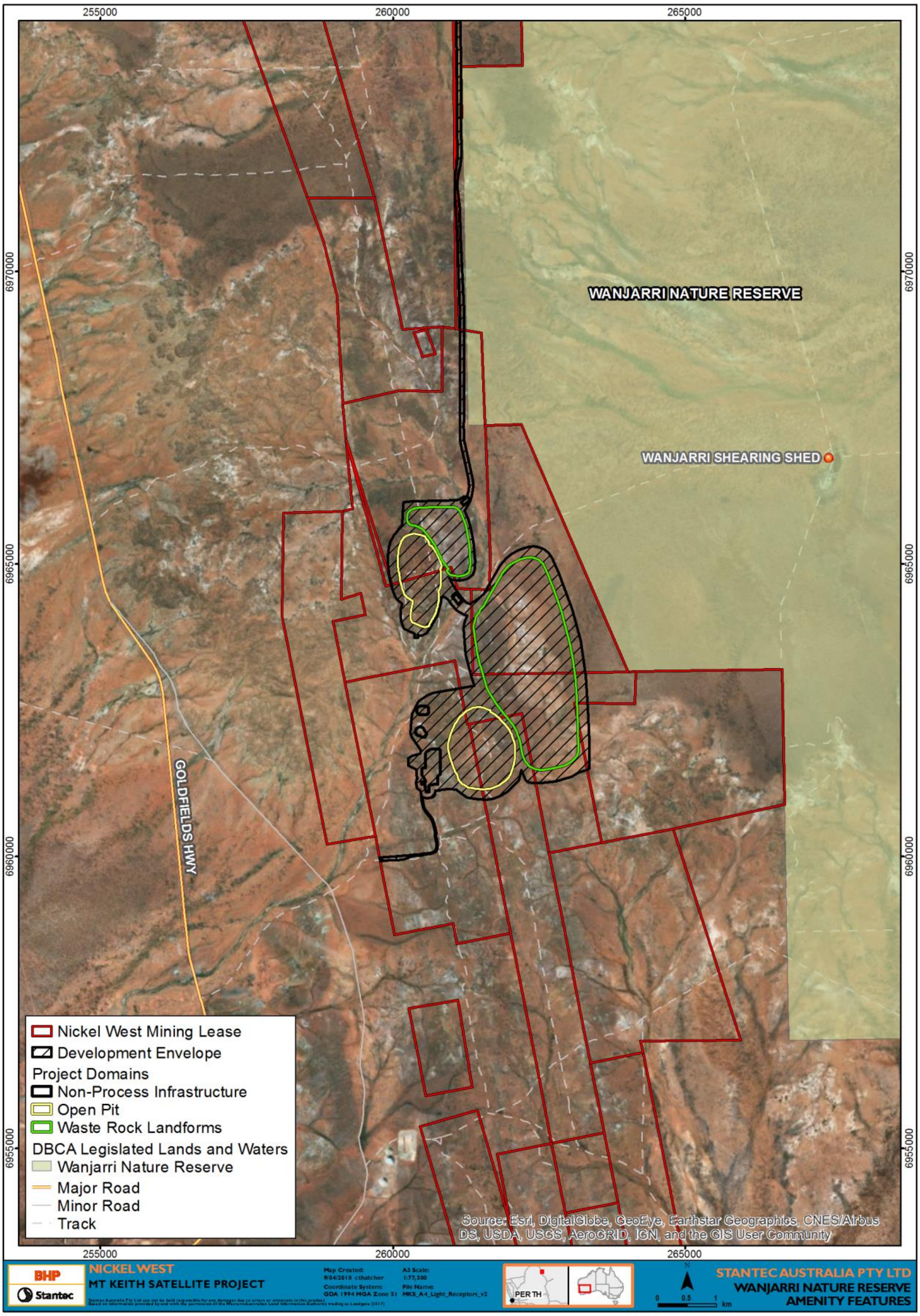


Figure 67 Location of light receptors

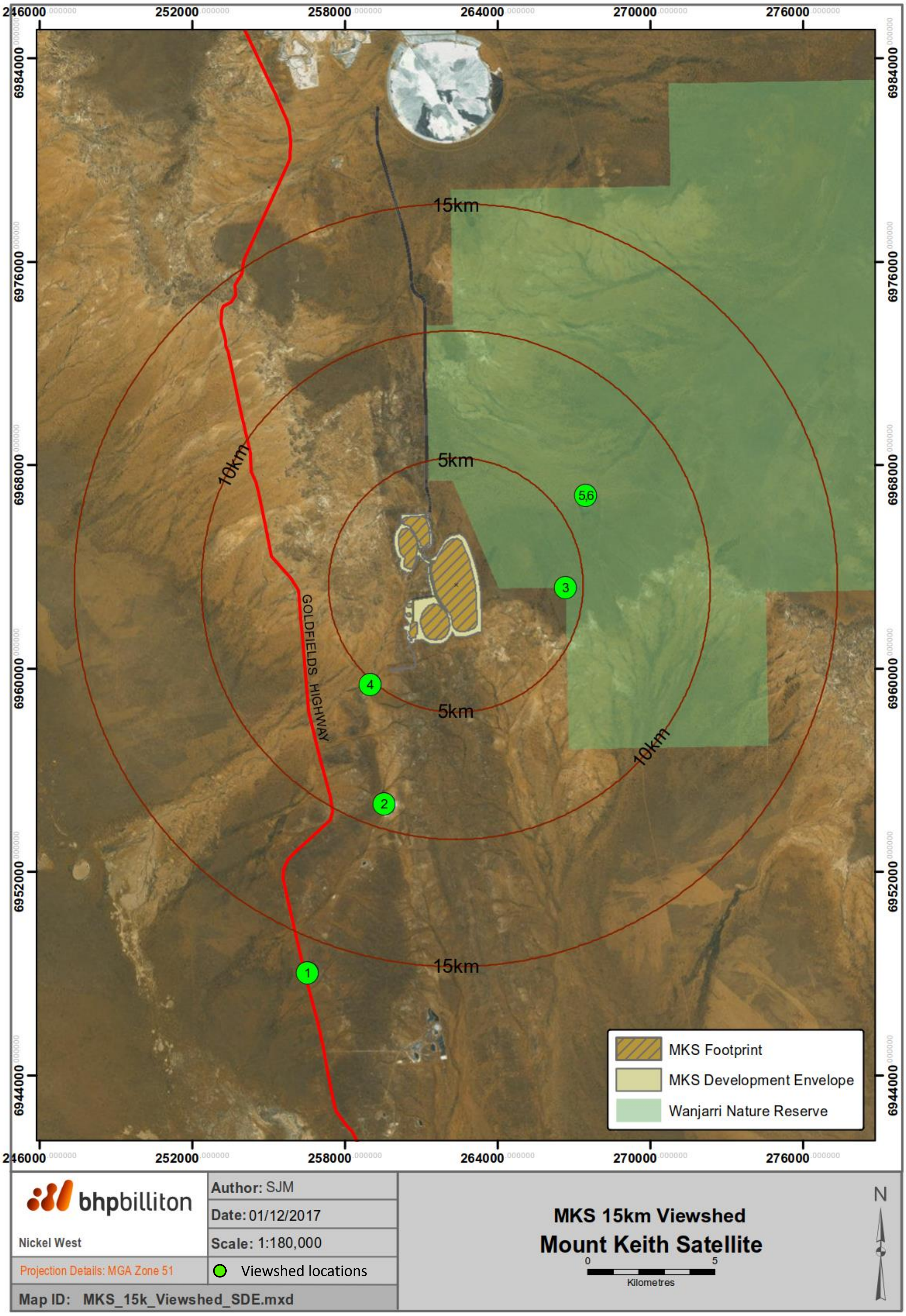


Figure 68 Visual impact assessment receptors

Table 56 Location of photomontage view points

Plate	View in Figure 68	Easting	Northing	Distance to WRL centre (m)	Description
7	1	20.4908	16538	16538	Entrance to proposed access track into Wanjarri Nature Reserve from Goldfields Hwy. Dense, obscuring vegetation. Waste rock landform not visible.
8	2	17.5834	9021	9021	Turn off near former Kathleen Valley townsite Sparse vegetation.
9	3	271.1148	4307	4307	Eastern boundary of NiW tenements. Closest point to the mining landform of all the photos locations
10	4	41.0149	5176	5176	View towards waste rock landform from old Goldfields Highway turnoff to southern access track.
11	5	235.2742	6210	6210	Wanjarri Homestead location. The DPaW track is 500m short of the homestead (due to swamp). Track is seasonal. This is where visitors may choose to park on first arrival
12	6	235.2742	6210	6210	A moderate walk (80m) from the Wanjarri Homestead, into a large grass clearing.

Plate 7: View towards waste rock landform from entrance to revised access track from Goldfields Hwy.

Plate 8: View towards waste rock landform from Kathleen Valley Townsite turnoff.

Plate 9: View towards waste rock landform from eastern boundary of BHP tenements.

Plate 10: View towards waste rock landform from old Goldfields Highway turnoff to southern access track.

Plate 11: View towards waste rock landform from Wanjarri Homestead location.

Plate 12: View towards waste rock landform clearing area approximately 80m walk from Wanjarri Homestead.

As can be seen from the photomontage series, the WRL will be visible from some vantage points along the access road into Wanjarri Nature Reserve within the 10km viewshed, particularly where there is sparse vegetation, and does not take into consideration, revegetation of the final landform. However, at the Homestead where visitors are likely to stop for recreational and camping use within the park, there is very limited visibility of the final landform. This is not considered to be a significant residual impact.

Access to Wanjarri Nature Reserve

The current access to Wanjarri Nature Reserve from the Goldfields Highway, traverses the southern portion of NiW's tenements, through the Proposal Disturbance Footprint. This route will no longer be accessible once the Proposal commences.

As early as 2005, BHP commenced discussions with the (then) Department of Conservation and Land Management (now DBCA) regarding the requirement for an alternative access route into Wanjarri Nature Reserve. An agreement was reached at that time for a route further to the south to ensure safe access for visitors and DBCA staff to the Reserve. It was agreed between both parties that NiW would fund access realignment, track upgrades and signage. The revised access route covers exiting tracks and is shown in Figure 69. The revised access was assessed by DBCA and BHP personnel and is a minor deviation to the route that was formally agreed in 2005.

As the Proposal was put on hold, this matter was not progressed further at that time. However, in June 2017, consultation with the DBCA Goldfields Region office recommenced to enable the earlier agreement between both parties to progress. This consultation is ongoing, with initial work involving discussion of a revised letter agreement and the installation of agreed signage on entry to the Proposal area advising that entry to the Reserve via the old access route is no longer allowed. The provision of an alternative access route ensures continued public access to the Reserve.

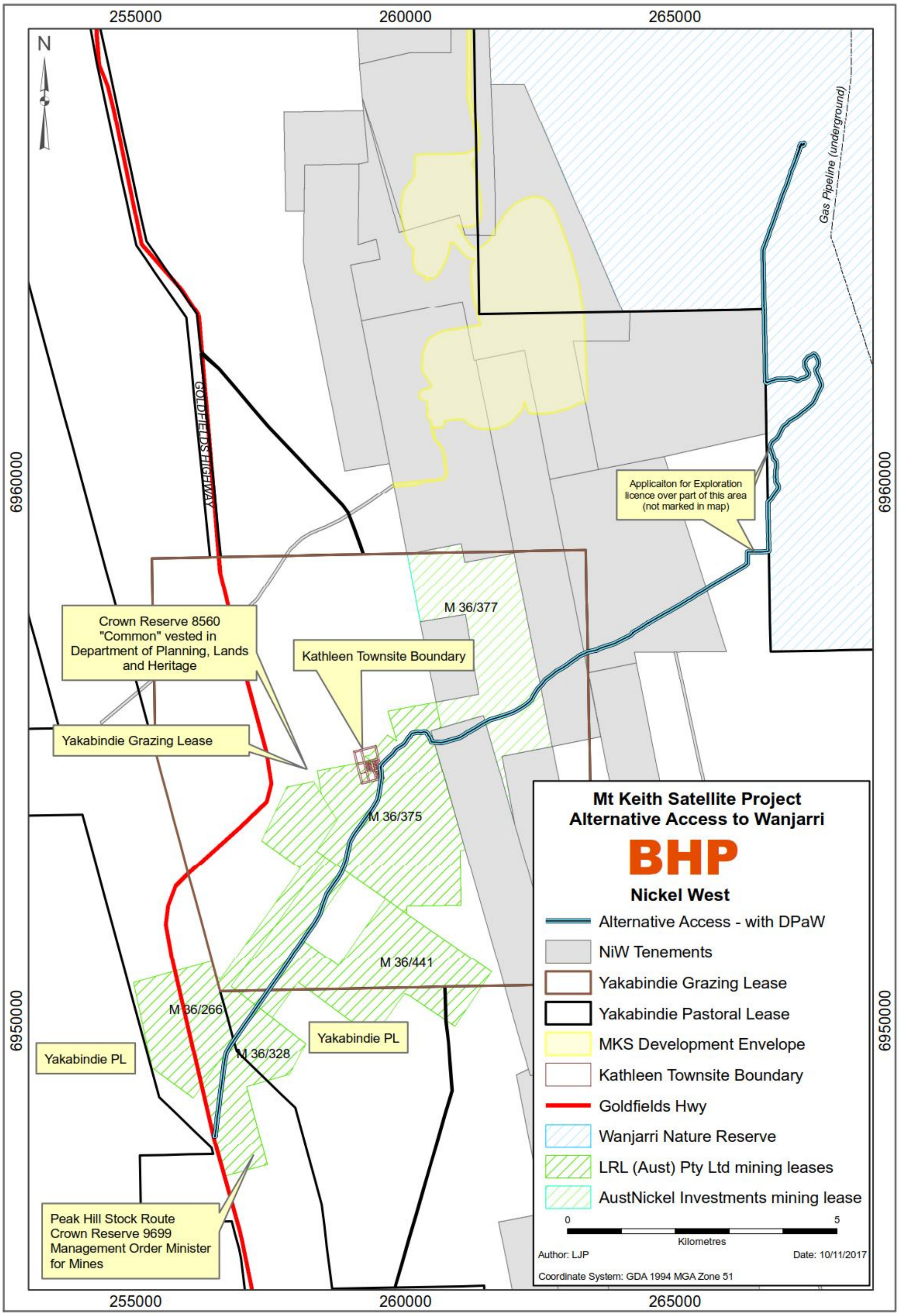


Figure 69 Alternative Access to Wanjarri

10.11 Wanjarri Nature Reserve - Mitigation, Residual Impacts and Outcomes

A summary of the key mitigation measures to address potential impacts to the amenity and recreational values of Wanjarri Nature Reserve are listed in Table 57. This includes consideration of mitigation strategies required to manage inherent impacts and residual impacts after the application of these measures.

Table 57 Environmental Management of Social Surroundings – Wanjarri Nature Reserve

EPA Objective	To protect social surroundings from significant harm **Aspect:** *visual amenity and the ability for people to live and recreate within their surroundings without any unreasonable interference with their health, welfare, convenience and comfort.*	Outcomes
Inherent Impacts Requiring Management	**Mitigation Strategies**	
Dust, noise, vibration and light emissions impacting on amenity of visitors to Wanjarri Nature Reserve. Visibility of the final waste rock landform from within the Reserve Interruption to public access to the Reserve.	**Avoid** • Provision of a safe, alternative access route into Wanjarri Nature Reserve. **Minimise** • Use of water based dust suppression on haul road, access ways and within mining areas. • Use of chemical stabilisation in water based dust suppression on haul road nearest the NMK camp • Speed controls on vehicle movements along the haul road to minimise dust generation. • Blasting charge sizes limited to ensure ground borne vibration levels remain within prescribed daytime and night-time limits as measured from the camping area within Wanjarri Nature Reserve. • Lighting limited to illumination of operational areas for safety requirements. **Rehabilitate** • Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	**Residual Impact** Amenity values can be highly subjective, with different levels of perception or tolerance of impacts. The residual impact of noise, dust and light emissions on the amenity of the Wanjarri Nature Reserve are considered to be low: • Noise emissions are expected to remain within prescribed limits for Wanjarri Nature Reserve. • Blasting vibrations are not expected to impact on the reserve, with appropriate charge controls in place. • Dust emissions are not expected to impact on visitor access to the Reserve and will be controlled along the western boundary of the Reserve where it abuts the haul road, through the use of water based dust suppression and speed limitation of vehicles. • Light emissions are expected to be limited to operational areas and rapidly dissipate with distance from the source. The most visible aspect of the Proposal will be the final waste rock landform. Visual impact assessment has found that it is likely this landform will be visible along some parts of the access into Wanjarri Nature Reserve inside the 10km viewshed, particularly where the vegetation is sparse. As vegetation density and distance increase, the landform is less visible. At key access points within the Reserve, being the Homestead and Shearing Shed, there is limited to no visibility of this landform. Continued, safe access to the Reserve will be maintained through an existing alternative access route. The residual impacts of the Proposal on the amenity values of Wanjarri Nature Reserve are minor and, with the exception of visibility of the final waste rock landform, can be mitigated with appropriate management measures. NiW considers that the EPA objectives for Social Surroundings as it relates to the values of Wanjarri Nature Reserve, can be met. **Offsets** Given the implementation of the Proposal is not considered to result in significant impacts to Wanjarri Nature Reserve, no offsets are proposed.

11 Other Environmental Factors

The following additional environmental factors relevant to the proposal have been identified for the Proposal and are discussed in the sections below:

- Ministerial Statement 117;
- Ministerial Statement 415 and existing Mt Keith Mine;
- Greenhouse Gas Emissions; and
- Mine Closure Planning.

11.1 Ministerial Statement 117

In 1990 the EPA assessed a proposal to mine nickel and process a low-grade nickel sulphide orebody in a similar location to the current Mt Keith Satellite Proposal within the Yakabindie Pastoral Lease. The 1990 proposal, referred to as the Yakabindie Nickel Proposal in Ministerial Statement 117, has not been implemented. The Proposal constitutes a substantial revision of the 1990 proposal, requiring referral under section 38 of the EP Act. Table 58 provides a comparison of the differences between the Yakabindie Proposal with the current Proposal.

Table 58 Comparison of differences between the Yakabindie and MKS Proposals

Element	Description of key YNP elements	Difference between the Proposal and YNP
Total area	The YNP approval is for an area of up to 5000 ha.	Proposal is limited to a Development Envelope of approximately 1259 ha.
Mine Pit	The YNP mine pit was located on Jones Creek, requiring the diversion of the creek.	The Proposal's Six Mile Well Pit avoids Jones Creek (excepting creek crossings).
Waste rock landforms	The YNP required the construction of two waste dumps (with the West Waste Dump extending outside the area of mine tenure held by the Proponent).	The Proposal only includes one waste rock landform.
Plant	The YNP included a processing plant to the west of the pit and would include crushing, grinding, conditioning and flotation to produce a nickel-rich concentrate.	The Proposal does not involve processing of ore (ore will be transported to the existing Mount Keith processing facility via a transport corridor).
Tailing Storage	A Tailings Storage Facility (TSF).	The proposal does not include a TSF (ore will be transported to the existing Mount Keith processing facility which includes a TSF).

11.2 Ministerial Statement 415 and existing Mt Keith Mine

Background

The Mt Keith Central Discharge Tailing Storage Facility (CDTSF) is currently conditioned under Ministerial Statement 415, issued on 7 May 1996. The current design capacity of the CDTSF is approximately 240 Mt and will sustain NMK processing operations until 2020.

As discussed in Section 2.3, the Proposal provides satellite ore to NMK, where the ore will be stockpiled prior to processing. All process tailings will be discharged to the existing CDTSF in accordance with current approvals for that facility.

The CDTSF was initially designed to operate as a centralised discharge type tailings facility, comprising an outer containment embankment 4,600m in diameter and 3m to 5m in height, carrying a ring main distribution pipe feeding spigot outlets along the perimeter as well as feeding nine vertical risers located within the storage facility. The nine vertical risers comprise a central riser pipe structure, four eastern riser pipes and four western riser pipes.

Following commissioning of the CDTSF it became evident the beach slope was not being achieved and the deposition method was not successful in keeping supernatant water (slurry water as well as storm water) away from the perimeter wall and towards the surface drains. An internal embankment was constructed to manage and control surface water away from the perimeter embankments, and as a measure to enhance tailings consolidation and minimise seepage impacts on the area surrounding the CDTSF. The inner wall was originally constructed using a mixture of tailings and oxide waste rock as construction material. Since construction of the original inner embankment and kidney wall, these structures have been raised on an ongoing basis, via upstream raising, through the placement of conditioned tailings material.

NiW believes that the changes to the CDTSF design are appropriately dealt with under Section 45C of the EP Act.

NiW is progressing the development of supporting information to accompany such an application and anticipates presenting to the EPA in late 2018 the results of its investigations, prior to submission of an application to change the Proposal under s45c of the EP Act.

The CDTSF is subject to the provisions of the Mining Act 1978. NiW would submit a Mining Proposal to the DMIRS to assess the CDTSF changes.

Design concept

The design concept being assessed by NiW involves the continual upstream lift of the internal embankment of the CDTSF, such that the overall footprint of the CDTSF would not be increased. The embankment would over the life of asset be raised to a height comparable to the original design of approximately 46 m above ground level. Buttressing of the wall would be applied to the exterior of the internal wall to ensure stability.

Based on the current Life of Asset plan for NMK additional tailings storage capacity will be required from 2020. NiW is in the process of assessing a concept design for the CDTSF that will provide for the Life of Asset tailings storage requirements for NMK to 2040.

Excavation, relocation, and re-installation of in-wall decant pipes and ad hoc adjustment of external infrastructure (access roads, access ramps, and decant pipes) are associated with the wall raise activities.

Effects of the change

The proposed change to proposal does not introduce any new environmental factors to those originally assessed. An assessment of the key environmental factors identified by the EPA and relevant to the proposed change is provided in Table 59.

The key environmental factors are listed as per the original assessment; however, they have been consolidated to align with current EPA policy and guidance (Environmental Factors and Objectives).

Table 59 Key environmental factors and relevance to proposed change to the CDTSF Proposal

Factor	Relevance to proposed Change to CDTSF Proposal
Flora and vegetation	The footprint of the CDTSF will not increase as a result of the proposed change, therefore direct impacts on flora and vegetation, land systems or Wanjarri Nature Reserve will not increase from the original proposal. Indirect impacts to flora and vegetation from changes to hydrological processes however requires consideration.
Terrestrial fauna	The footprint of the CDTSF will not increase as a result of the proposed change, therefore direct impacts on terrestrial fauna and fauna habitat will not increase from the original proposal. Indirect impacts to fauna habitat from changes to hydrological processes however requires consideration.
Hydrological processes	No changes to surface water management. Changed TSF design and additional capacity has the potential to affect groundwater seepage and mounding.
Closure and rehabilitation	Post-closure and rehabilitation planning likely to require amendment in respect of redesign.

A preliminary assessment of significance of the impacts of the changes to the CDTSF has been completed and is presented in Table 60.

Table 60 Significance assessment of CDTSF changes

Criteria	Proposed CDTSF Expansion
Values, sensitivity and quality of the environment which is likely to be impacted	Flora and vegetation and fauna No conservation significant flora and vegetation or habitat for conservation significant fauna was identified during the assessment of the original proposal. No flora, vegetation, land systems or fauna habitat were restricted to the Proposal area and were considered widespread. The change to proposal will not result in any change to the extent of direct impacts to flora and vegetation or terrestrial fauna. It was also determined that the facility was located at a sufficient distance from Wanjarri Nature Reserve such that no direct impacts would occur from construction activities. Construction activities will remain at distance from the reserve and therefore this assessment remains current. Hydrological Processes Three aquifers are known to exist in the broader Albion Downs Basin, namely: Alluvial, shallow, unconfined low-permeability aquifers within the broad areas of valley fill surface sediments, characterised by salinities ranging between 2,000mg/L and 5,000mg/L; Narrow semi-confined paleochannel aquifers of moderate permeability, existing at the base of the valley fill sedimentary sequence, with salinities ranging between 5,300mg/L and 132,000mg/L; More or less hydraulically isolated, deep lower regolith fractured bedrock aquifers, containing saline-hypersaline groundwater. The Ultramafic Caprock aquifers overlay the Ultramafic Belt and are highly variable even over short distances. In areas close to NMK the saturated thickness of the aquifer zone varies between 30m and 50m, with salinities ranging between 1,500mg/L and 2,000mg/L. There were no downstream beneficial uses of groundwater. No natural permanent surface waterbodies are present in the area. Storm water runoff drains across the NMK site to the east and south-east, in both identifiable streams, and as sheet flow from the Breakaways. The change to proposal will not affect management of stormwater.
Extent (intensity, duration, magnitude and geographic footprint) of the likely impacts (of the proposed change)	Flora and vegetation and fauna No further clearing or disturbance is required as a result of the change to proposal. The change to proposal will not result in any change to the extent of direct impacts to flora and vegetation or terrestrial fauna. Hydrological Processes Based on modelling, seepage is predicted to extend to a distance of around 1.1 km south of the CDTSF and would reach Wanjarri Nature Reserve (at depth) after 2040. Root zone impacts are more proximate to CDTSF and within a 400 m of footprint of the facility. Surface expression of seepage affecting vegetation appears to be lessened by new design and would be anticipated to manage residual impacts on flora and vegetation due to hydrological processes. Seepage from the existing facility has been effectively managed to date through implementation of additional measures to those originally anticipated. These measures are anticipated to be effective in the ongoing management of seepage in extending the life of the CDTSF with the new design proposal. This may be further improved with optimisation of interception trenches. The overall effects of the Proposal are not expected to be significant at a local or regional level.
Consequence of the likely impacts (or change)	Flora and Vegetation Water table has risen within 3m of surface within 205 m of the external embankment. Seepage has resulted in 16.1 ha of vegetation impacted, with some mortality along southern edge. Extension of groundwater levels within 3m of surface from 205 m to within 345 m of the external embankment may result in up to a 68% extension of root zone impacts to the south. Indirect impacts of seepage affecting vegetation appears to be lessened by the new design and would be anticipated to manage residual impacts on flora and vegetation due to hydrological processes due to the revised proposal. Hydrological Processes Modelling shows continued lateral movement of seepage to the south, but surface expression of seepage affecting vegetation may be lessened by new design.
Resilience of the environment to cope with the impacts or change	Flora and Vegetation No further clearing or disturbance is required as a result of the change to proposal. The change to proposal will not result in any change to the extent of direct impacts to flora and vegetation or terrestrial fauna. Hydrological Processes Modelling shows continued lateral movement of seepage to the south, but surface expression of seepage affecting vegetation may be lessened by new design.
Cumulative impact with other projects	NMK is located within an isolated area of the Northern Goldfields, within the Shire of Wiluna, 720 km from Perth and 430 km north of Kalgoorlie. The closest town (Wiluna) and operating mine (Apex Wiluna Gold) are located 85 km to the north. Several exploration and feasibility ventures are located within the region, but none are within 50 km of NMK.
Connections and interactions between parts of the environment to inform a holistic view of impacts to the whole environment	Nexus between hydrologic impacts and vegetation effects is important. However, vegetation is still widely distributed and represented elsewhere in the region. Demand for groundwater use in area is not anticipated. Residual impacts on Wanjarri Nature Reserve will be given further consideration in the s45C process, but the nexus to receptors and vegetation is unlikely to be significant.
Level of confidence in the prediction of impacts and the success of proposed mitigation	Based on the work of Golder (2018), there is substantial confidence on the conclusions. More work may be required to better understand post closure seepage and management for approvals.

Criteria	Proposed CDTSF Expansion
Public interest about the likely effect of the proposal, if implemented, on the environment, and public information that informs the EPA's assessment.	Low level of public interest in original proposal. High level of interest at the time from Department of Conservation and Land Management (CALM). Potential for public interest from conservation groups and native title claimants. Department of Biodiversity, Conservation and Attractions - Parks and Wildlife Service (DBCA) likely to show interest in proposal given potential for vegetation impacts and concerns related to Wanjarri Nature Reserve. Informed stakeholder consultation will be required.

11.3 Greenhouse Gas Emissions.

In order to the meet the EPA objective for Air Quality, that is to maintain air quality and minimise emissions so that environmental values are protected, consideration of greenhouse gas emissions from the Proposal has been undertaken.

Emissions of greenhouse gases contribute to the changing climate. The effects of the changing climate are predicted to be significant in Western Australia, with a drying climate in the south-west, more frequent and severe storms in the north-west, and a rising sea level along our entire coastline.

Greenhouse gas emissions resulting from the Proposal will be generated through the combustion of hydrocarbons, clearing of native vegetation, the use of explosives during blasting operations and the use of electricity.

The maximum annual emission of greenhouse gases for the Proposal over the life of the mine is predicted to be equivalent to 525 kilotonnes of carbon dioxide (CO_2-e). This corresponds to 0.13% of Australia's reported emissions for the period FY2015-16 (Clean Energy Regulator, 2017) or 0.61% of Western Australia's financial year 2015 greenhouse inventory (Department of the Environment and Energy, 2017). The average CO_2-e emissions (scope 1 & 2) for the proposal over the life of the mine is predicted to be 353 kilotonnes of CO_2-e per annum (or 0.41% of Western Australia's emissions on average). The greenhouse gas emissions predicted for the life of the Proposal are depicted in Figure 70 and Figure 71.

The proposed greenhouse gas emissions are not considered significant in the context of either Western Australia or Australia's annual reported emissions.

The average carbon emissions intensity of the proposal are predicted to be 6.15 t CO_2-e per tonne of nickel metal. Benchmark carbon emissions intensities for nickel vary depending on factors such as ore type (sulphide or laterite), ore grade and other orebody characteristics. Despite having a lower ore grade the average emissions intensity of the proposal is within the middle of the range when comparing emissions intensity to other sulphide proposals (Figure 72).

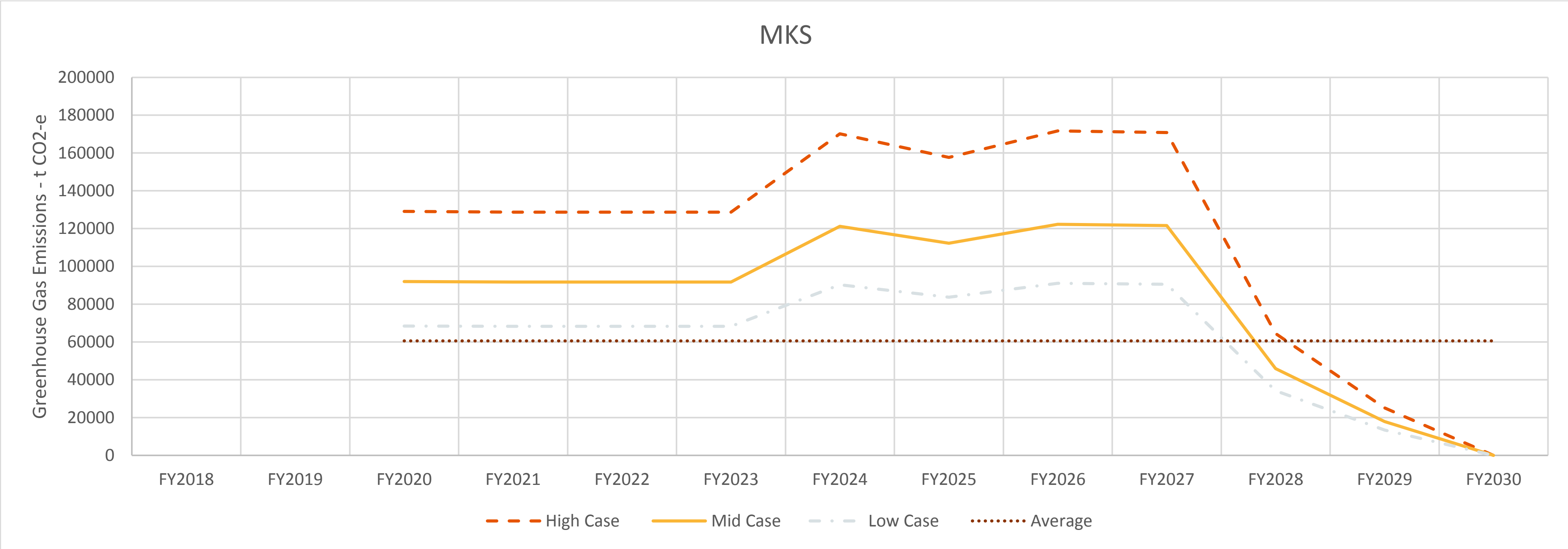


Figure 70 Summary of greenhouse gas emissions only

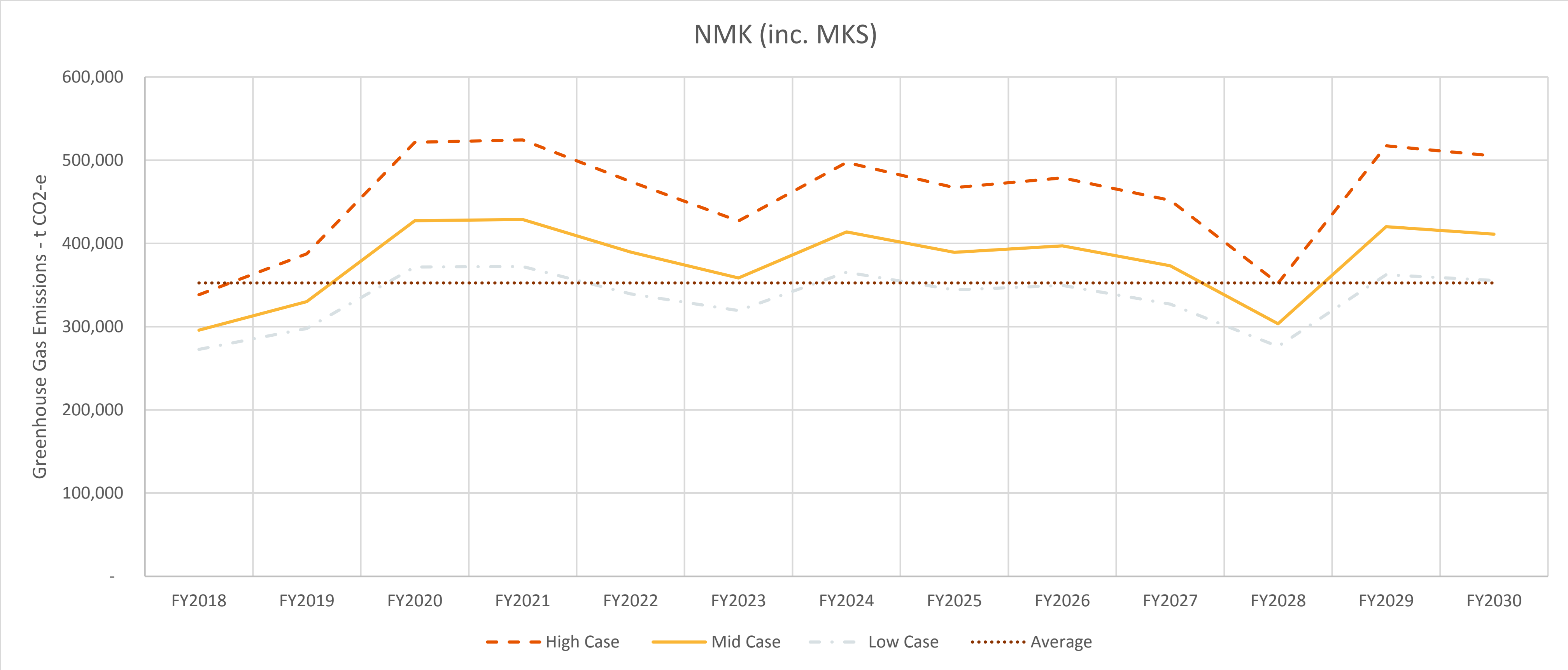
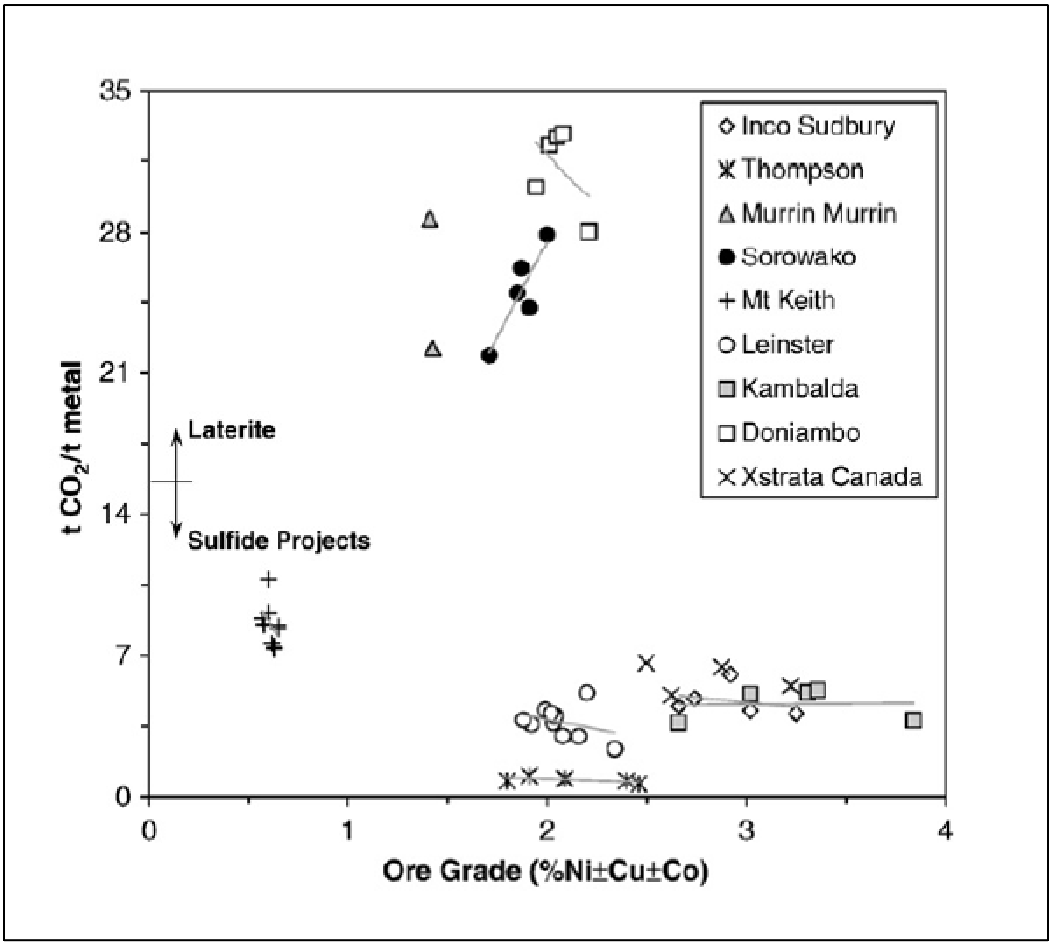


Figure 71 Summary of greenhouse gas emission NMK and MKS combined



Mudd, GM 2010

Figure 72 Global trends and environmental issues in nickel mining: sulphides versus laterites

11.4 Mine Closure Planning

As noted in Section 2.3, preliminary mine closure planning has been completed for the Proposal and resultant MCP (Appendix E) provides initial completion criteria and closure options, supported by preliminary mine designs, geochemical waste characterisation, and conceptual and numerical hydrological modelling. The MCP has been developed in accordance with DMIRS and EPA *Guidelines for Preparing Mine Closure Plans* (2015) and addresses the objectives of the preliminary key environmental factors of flora and vegetation, terrestrial fauna, hydrological processes and inland water environmental quality.

Key outcomes of the MCP are identified post mining land uses, closure objectives and performance criteria.

Selected post mining land uses

Table 61 identifies the proposed post mining land uses for the Proposal, and will be subject to review over time to ensure their continued relevance, feasibility and agreement with key stakeholders.

Table 61 Proposed post mining land-uses

Domain	Land-Use	Description
WRL	Self-Sustaining Native Vegetation (to support local biodiversity and improved post-mining aesthetics)	Will support self-sustaining native vegetation (i.e. native vegetation species, which can survive in local conditions with nil to minimal maintenance or other intervention, will be predominant). The land-use objective is to maintain local biodiversity whilst improving/softening the visual aesthetics of mine rehabilitation. Grazing will be discouraged (from perimeter fencing of the landform) to reduce potential for grazing impacts to undermine core stability and revegetation/biodiversity outcomes. Use of native species unpalatable to stock will be considered in the adopted seed mix. This land-use will not inhibit or adversely impact the pastoral activity in surrounding non-mined areas. Funding provisions will be made for maintenance of fencing and other key features for a finite period beyond the post-closure monitoring phase to support a successful relinquishment process for mining tenements and residual liabilities.
Open Pit	Historic Mining (to preserve mining history and support potential resumption of mining or alternate uses)	Mining void and immediate area will be made safe and stable with access for people and stock discouraged through fencing / bunds (e.g. at top of pit access ramps, abandonment bund) and rehabilitation of former access roads. The final void will be left to serve as a pit lake, which could be dewatered to support any future resumption of mining. This land-use will not inhibit or adversely impact the pastoral activity in surrounding non-mined areas.
Non-Process Infrastructure	Self-Sustaining Native Vegetation (to support low intensity cattle grazing)	As above. Additionally, it may, where feasible and sought by key stakeholders, support a transition to low intensity pastoral grazing over time. If the pastoral benefit is more limited than was envisaged for some areas, this will be considered in the justification or not of continuing to pursue a grazing outcome over time particularly where alternate benefits are evident (e.g. biodiversity). It is anticipated that larger Non-Process Infrastructure areas will be initially fenced to enable vegetation to establish and develop until it is able to support limited grazing where this is deemed feasible as an extension to surrounding pastoral lands.

Closure objectives

Realistic and achievable closure objectives have been developed, which are consistent with the post-mining land-uses and will be refined in further iterations of the MCP. Closure objectives have been developed at the site (broad) and key domain (specific) levels, and are provided in Table 62. The Domain Objectives are grouped according to the Site Objective tenets - safe, stable, non-polluting and agreed land-use. Compliance with legal and other (e.g. NiW) obligations is a primary requirement of the Site Objective.
The Proposal has been classified into common disturbance types, which are referred to as closure domains, as defined in Table 62:

Table 62 MKS Closure Domains

Landforms	Open Pits	Non process infrastructure
WRL ROM Pad	Six Mile-Well Open Pit Goliath Open Pit	• Administration Buildings; • Fuel Farm; • Dewatering Facility; • Bridge Crossings (North and South); • Drainage Controls; • Unsealed Roads; • Haul Road to NMK (20 km); • Laydown areas; and • Topsoil Stockpiles.

Table 63 provides the closure objectives at site and domain level. Further information is provided in Appendix E.

Table 63 Closure Objectives

SITE Objective
Deliver safe, stable and non-polluting outcomes and agreed post-mining land-use/s[1] that comply with legal and other obligations and achieve mining tenement relinquishment[2] and a "walk away" solution[3] for NiW.
[1] *"Safe, stable and non-polluting outcomes"* are defined as: - *"Safe" includes the protection of people from harm primarily but also gives consideration to stock and native fauna;* - *"Stable" encompasses erosional and geotechnical stability, and* - *"Non-polluting" is both geochemical and geophysical and considers sources, pathways and sensitive receptors to qualify risk.* [2] *"Mining tenement relinquishment" is defined as a state when agreed completion criteria have been met, government "sign-off" achieved, all obligations under the Mining Act 1978 removed, and the proponent has been released from all forms of security. This is consistent with the definition of "relinquishment" provided in the DMIRS / EPA "Guidelines for Preparing Mine Closure Plans May 2015".* [3] *"Walk away solution" is defined as a state when mining tenement relinquishment has been achieved and NiW has been able to reliably discharge to the State Government or other third party its residual liabilities related to the site. At this time, the site shall either no longer require management, or if further management is required or can be reasonably expected then NiW shall make adequate provision so that the required management can be undertaken with no unacceptable outcome to the third party which inherits the site.*
DOMAIN Objectives
All Domains
Safe • Materials harmful to human health will be encapsulated or remediated. • Final landforms and land-use/s will not pose unacceptable risks to people or fauna. • Infrastructure will be removed unless agreed to by regulators and post-relinquishment land owners/managers.
Stable • Final landforms will be geotechnically stable. • Erosion stability will be achieved by controlling surface run-off and low stability materials.
Non-Polluting • Seepage will not harm sensitive groundwater receptors. • Surface water run-off will not harm the surrounding environment. • Materials harmful to the environment will be encapsulated or remediated.

Agreed Land-Use
• The post-mining land-use/s will be agreed with key stakeholders.
• The final landforms will not adversely impact surrounding pastoral land-use.
• Revegetated areas will support self-sustaining vegetation dominated by native species.
• Revegetation of rehabilitation areas and other initiatives will seek to maintain local biodiversity.

Closure Performance Criteria

Closure performance criteria are based on the post-mining land-uses and closure objectives. These criteria are intended to be realistic, risk-based and fit-for-purpose for site conditions. The closure performance criteria proposed for MKS are identified in Table 64.

As completion of mining approaches, closure criteria will be reviewed and reflected in the execution of detailed closure designs.

Table 64 MKS Closure Completion Criteria

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
Safety	Materials harmful to human health will be encapsulated or remediated	- An inert cover will be applied over all exposed deleterious materials (e.g. contaminated soil, PAF waste rock, hazardous wastes)	Covers are constructed per detailed design specifications approved by regulatory authorities	No exposed material harmful to human health is observed	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the Basis of Design (BoD) and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations. This will include a validation assessment report from the CSA for components that relate to contaminated sites remediation. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. This will include a validation assessment report from the CSA for components that relate to contaminated sites remediation.
	Final landforms and land-use/s will not pose unacceptable risks to people or fauna.	- Rehabilitated (embankment) slopes will be no greater than 20º. - Stock proof fencing of the WRLs and open pit. - Construction of an abandonment bund around the open pit. - Construction of bunds at the top of pit access ramps. - Access roads will be closed and rehabilitated when they are no longer required to mitigate access.	Final landforms are constructed per detailed design specifications approved by regulatory authorities.	No unacceptable safety risks from final landforms and land-use are identified post-execution.	- (Pre-Execution) Independent Quality Assurance (QA) audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field
	Infrastructure will be removed unless agreed to by regulators and post-mining land owners/managers.	- Above ground infrastructure will be removed unless otherwise agreed. - Below ground infrastructure will be removed, decommissioned or	Site infrastructure is removed per detailed design specifications approved by	No infrastructure remaining post-execution unless agreed to	- (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
		buried up to 0.5 m below ground level (bgl).	regulatory authorities.		- (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field
Stability	Final landforms will be geotechnically stable.	- WRL designs to achieve a minimum post closure FoS of 1.3 under static conditions.	Final landforms are constructed per detailed design specifications approved by regulatory authorities.	No WRL material is within the ZoI.	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field
	Erosion stability will be achieved by controlling surface run-off and low stability materials.	- WRL top surface designs will retain incidental rainfall from a critical duration PMP event. - WRL berm designs will retain incidental rainfall from a critical duration 1:1,000 year ARI rainfall event. - Surface water diversion structures will mitigate erosion risk to critical landform features. - A rock cover will be applied to all exposed tailings. - WRL embankment surfaces will consist of durable rock. - WRL embankment slopes will be no greater than 20°.	Final landforms are constructed per detailed design specifications approved by regulatory authorities.	Surface erosion is within predicted rates or the assimilative capacity of landforms.	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Site technical audits and reports by suitably qualified person/s at 5 years and 10 years post-execution to verify the predicted rates of erosion are being achieved or are within the assimilative capacity of landforms (note, auditing will be maintained minimum 5 yearly thereafter if this has not been demonstrated within 10 years).
Non-Polluting	Seepage will not harm sensitive groundwater receptors.	- Modelling at NMK confirms that the pit lake in the final void will not cause harm post-closure to	Rehabilitation and remediation works are completed per detailed design	Local groundwater quality is within predicted quality ranges with no	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations. This will include a

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
		sensitive groundwater receptors including active stock bores. - Contaminated soil exceeding remediation criteria, protective of sensitive groundwater receptors and agreed with a CSA and DMIRS, will be removed up to 0.5 m bgl.	specifications approved by regulatory authorities.	harm to sensitive receptors evident.	validation assessment report from the CSA for components that relate to contaminated sites remediation. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. This will include a validation assessment report from the CSA for components that relate to contaminated sites remediation. - (Post-Execution) Site technical audits and reports by suitably qualified person/s at 5 years and 10 years post-execution to verify no harm is caused to sensitive groundwater receptors (note, auditing will be maintained minimum 5 yearly thereafter if this has not been demonstrated within 10 years).
	Surface water run-off will not harm the surrounding environment.	- WRL top surface designs will retain incidental rainfall from a critical duration PMP event. - WRL berm designs will retain incidental rainfall from a critical duration 1:1,000 year ARI rainfall event. - Contaminated soil exceeding remediation criteria, protective of sensitive groundwater receptors and agreed with a CSA and DMIRS, will be removed up to 0.5 m bgl.	Final landforms are constructed per detailed design specifications approved by regulatory authorities.	Surface erosion is within predicted rates or the assimilative capacity of landforms.	- - (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations. - - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Site technical audits and reports by suitably qualified person/s at 5 years and 10 years post-execution to verify the predicted rates of erosion are being achieved and to verify that surface water / runoff does not harm the surrounding environment

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
					(note, auditing will be maintained minimum 5 yearly thereafter if this has not been demonstrated within 10 years).
	Materials harmful to the environment will be encapsulated or remediated.	- An inert cover will be applied over all exposed deleterious materials (e.g. contaminated soil, PAF waste rock, hazardous wastes). - Contaminated soil exceeding remediation criteria, protective of sensitive groundwater receptors and agreed with a CSA and DMIRS, will be removed up to 0.5 m bgl.	Covers are constructed per detailed design specifications approved by regulatory authorities.	No exposed material harmful to the environment is observed.	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations. This will include a validation assessment report from the CSA for components that relate to contaminated sites remediation. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. This will include a validation assessment report from the CSA for components that relate to contaminated sites remediation.
Agreed Land-Use	The post-mining land-uses will be agreed with key stakeholders.	- Agreement with key stakeholders is obtained for the post-mining land-uses (or in the event of inconsistency in views between some stakeholders the DMIRS is supportive of proposed land-uses).	Landforms to support agreed land-uses are constructed per detailed design specifications approved by regulatory authorities.	Post-mining land-uses approved by regulatory authorities are achieved over time.	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations and agreed land-use. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Site land-use assessments and reports by suitably qualified person/s at 5 years and 10 years post-execution to confirm that the predicted land characteristics to support the proposed land-uses are in place or with time would support the proposed end land-uses (note, auditing will be maintained minimum 5 yearly thereafter if this has not been demonstrated within 10 years).

Closure Objectives		Closure Performance Criteria Pre-Execution (DPS)	Execution	Post-Execution	Measurement
	The final landforms will not adversely impact surrounding pastoral land-use.	- Final landforms will be designed protective of active stock water bores in surrounding areas. - Final landforms will be designed protective of surface water run-off quality to surrounding areas. - WRLs and the open pit will be fenced to exclude stock (cattle). - Pastoral improvement opportunities for surrounding areas will be adopted to increase the benefits from closure to local pastoralism.	Closure activities are completed per detailed design specifications approved by regulatory authorities.	No adverse impacts from final landforms to the pastoral land-use on surrounding lands is observed.	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations and causing no adverse impact on surrounding pastoral land-use. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Land-use assessments and reports by suitably qualified person/s at 5 years and 10 years post-execution to confirm that no adverse impact from the final landforms to surrounding pastoral activities is taking place (note, auditing will be maintained minimum 5 yearly thereafter if this has not been demonstrated within 10 years).
	Revegetated areas will support self-sustaining vegetation dominated by native species.	- Seed mixes for revegetated areas will include representative taxa from local vegetation communities. - Seed mixes will be optimised from rehabilitation trials conducted during operations.	Rehabilitation activities are completed per detailed design specifications approved by regulatory authorities.	- Weeds will not compromise the target diversity and density of native perennial vegetation species. The targets will be determined in consultation with and to the satisfaction of the DMIRS based on objectives that achieve rehabilitation areas	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations and the revegetation specification - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Rehabilitation assessments conducted post wet season (end of summer) and reports by suitably qualified person/s on an annual basis for three years post-execution then at 5 years and 10 years post-execution to confirm revegetated areas are low in weed density (achieving prescribed targets agreed with the

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
				where weeds are low in density and comparable with analogue sites and do not provide an ongoing source of weed invasion for adjacent areas of environmental sensitivity. - Nil to minimal maintenance of rehabilitated areas for weeds and to maintain plant vigour is required beyond the establishment of perennial species.	DMIRS), self-sustaining (i.e. require minimal to nil maintenance) and are not providing an ongoing source of weed invasion for adjacent areas of environmental sensitivity, including the Nature Reserve, PEC and significant flora. Auditing will be maintained minimum 5 yearly until performance objectives are achieved if not demonstrated within the initial 10 years.
	Revegetation of rehabilitation areas and other initiatives will seek to maintain local biodiversity.	- Seed mixes for revegetated areas will include representative taxa from local vegetation communities. - Seed mixes will be optimised from rehabilitation trials conducted at NiW nearby sites.	Rehabilitation activities are completed per detailed design specifications approved by regulatory authorities.	- Establishment of key structural vegetation species, diversity and cover trending toward appropriate analogue sites. Analogue sites are to be agreed with the DMIRS. - Revegetation in rehabilitation areas demonstrates	- (Pre-Execution) Independent QA audit* and report to verify that the detailed design is consistent with the BoD and other stated criteria and will achieve the closure objectives, including compliance with relevant legal obligations and maintaining local biodiversity. - (Execution) As-Constructed Report by the contractor to verify compliance of completed works in accordance with the approved design specifications. - (Execution) Independent QA audit* and report to verify that the findings of the As-Constructed Report are accurate and consistent with observations/evidence in the field. - (Post-Execution) Rehabilitation assessments conducted post wet season (end of summer) and reports by suitably qualified person/s

Closure Objectives		Closure Performance Criteria			Measurement
		Pre-Execution (DPS)	Execution	Post-Execution	
				viability through propagule development and seedling recruitment as demonstrated by observed and recorded evidence of reproduction, for mature plants (e.g. fruit, seed or flowers) and native perennial seedlings (second generation), or as otherwise agreed with the DMIRS.	on an annual basis for three years post-execution then at 5 years and 10 years post-execution to confirm revegetated areas generally represent the perennial plant cover and diversity found in the site locale. Auditing will be maintained minimum 5 yearly until performance objectives are achieved if not demonstrated within the initial 10 years.

Table 65 Post closure monitoring and rehabilitation schedule

ASPECT	ACTIVITY DESCRIPTION	MONITORING YEARS POST-EXECUTION										
		1	2	3	4	5	6	7	8	9	10	11
SAFETY												
Site Safety	Visual inspections to confirm abandonment bund integrity, condition of perimeter fencing and signage and indicators of unauthorised entry. Verify no exposed hazardous materials (previously covered or buried) and no steep-sided erosion gullies or other features outside of fencing that pose an unacceptable safety risk to persons, stock or native fauna.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
STABILITY												
Geotechnical Stability	Verify geotechnical performance is within predicted ranges. To be verified via field inspections and analysis of broad-scale survey data by a suitably qualified geotechnical engineer/s.	✓	✓	✓	✓	✓		✓			✓	
Erosional Stability	Verify landform erosion is within predicted rates. This is to include erosion within and resulting from surface water structures. To be verified via field inspections and analysis of broad-scale (e.g. aerial) survey data by a suitably qualified engineer/s, with further assessment as required.	✓	✓	✓	✓	✓		✓		✓		
NON-POLLUTING												
Surface Water Quality	Verify the quality of surface water run-off from final landforms is not adversely impacting any downstream sensitive receptors and is within the assimilative capacity of the landscape. To be verified via field inspections, and sampling / lab analysis as required.	✓	✓	✓	✓	✓		✓		✓		
LAND USE												
Biodiversity	Monitoring of rehabilitated and analogue areas to assess plant cover, density and species richness against target criteria.	✓	✓	✓	✓	✓		✓		✓		

ASPECT	ACTIVITY DESCRIPTION	MONITORING YEARS POST-EXECUTION										
		1	2	3	4	5	6	7	8	9	10	11
	Monitoring will also verify established vegetation is self-sustaining. To be verified via field survey / inspections and broad-scale (e.g. aerial) survey data.											
Weeds and Feral Animals	Monitoring of infestations of weeds and feral animals to inform maintenance activities.	✓	✓	✓	✓	✓		✓		✓		
REPORTING												
Annual Environmental Report	Annual summary of the results from closure monitoring and maintenance activities, including assessment against closure performance criteria.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Periodic QA Audit Reports	QA audit reports, completed by suitably qualified person/s approved by the DMIRS, to assess cumulative monitoring results to verify compliance with closure performance criteria, and as a basis to support the timely and effective relinquishment of mining tenements and residual liabilities.					✓					✓	
Closure Completion (Relinquishment) Report	After the final periodic QA Audit Report has been accepted by the DMIRS as confirming closure performance criteria have been met, this Closure Completion Report will consolidate the collective results from all monitoring, inspections, observations and maintenance activities conducted post-execution, and the periodic QA audit reports submitted to the DMIRS. The purpose of this report is to provide a consolidated report to the DMIRS (and other relevant parties, including agencies that represent the future land owner / manager e.g. DPLH) that collates all relevant information to demonstrate that the closure objectives and performance criteria have been met, providing the basis for relinquishment of mining tenements and the transfer of residual liabilities (the latter subject to terms and conditions of a specific legal agreement) to the State Government or another third party.											✓

12 Offsets

12.1 EPA objective, policies and guidelines

Environmental offsets, as defined in the 2014 *Western Australian Environmental Offset Guidelines* (Offset Guidelines), are actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a Proposal or activity. Unlike mitigation actions which occur on-site as part of the Proposal and reduce the direct impact of that Proposal, offsets are undertaken outside of the Proposal area and counterbalance significant residual impacts.

Environmental offsets will only be applied where the residual impacts of a Proposal are determined to be significant, after avoidance, minimisation and rehabilitation have been pursued. To ensure consistency and transparency of whether offsets should be applied to a Proposal, the significance of residual impacts has been determined through the application of the residual impact significance model provided in the Environmental Offsets Guideline. This model outlines how significance is determined and when an offset is likely to be required, or may be required, in relation to relevant EPA environmental factors and the relevant clearing principles in Schedule 5 of the EP Act (Government of WA, 2014).

The mitigation hierarchy of 'avoid, minimise, rehabilitate and offset' has been considered in the assessment of this Proposal. This will continue to be applied during the implementation phase, as far as reasonably practicable, such that impacts are first avoided, then minimised, rehabilitated and finally offset if significant residual impacts are unavoidable. This approach is consistent with the EPA guidance and State government policy.

12.2 Consideration of offset principles

The information presented here is to inform the assessment and decision making process in relation to the use of environmental offsets. This decision-making is underpinned by the principles stated within the WA Environmental Offsets Policy (Government of Western Australia, 2011), for which consideration of those principles for this Proposal are presented in **Table 66**. The assessment of the significance of residual impacts is provided in Section 12.3.

Table 66 Consideration of offset principles

Offset Principles	Consideration
1. Environmental offsets will only be considered after avoidance and mitigation options have been pursued.	Avoidance and mitigation measures have been applied and are described in Table 67. The residual impacts of the proposal are discussed in the context of quality, conservation significance, land tenure and timescale.
2. Environmental offsets are not appropriate for all projects.	In 2011, NiW entered into a land swap agreement with the Government of Western Australia to create a mining reserve for the future mining associated with the Proposal. This land swap involved an excision area comprised of 1.4 per cent of the total area of the Wanjarri Nature Reserve, and an inclusion area being 10 times the size of the excision area with significant conservation values (Figure 73). This land swap was partially implemented by the Reserves (Wanjarri Nature Reserve) Act 2012 which created the excision area. NiW is required under the land swap agreement to surrender the inclusion area when requested by the State to enable it to be incorporated into the Wanjarri Nature Reserve, and to manage the area in the meantime in a manner that ensures the conservation values of the area are not degraded. NiW believe that the land swap is an important consideration in determining whether offsets are

Offset Principles	Consideration
	appropriate for the Proposal. Additionally, through the application of the mitigation hierarchy, it is shown that the Proposal's impacts would be mitigated and rehabilitated so as not to be significant. In view of the above, no offsets are proposed.
3. Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.	No offsets are proposed.
4. Environmental offsets will be based on sound environmental information and knowledge.	Investigations undertaken for the Proposal have been completed by competent persons in accordance with relevant guidance and standards, as specified in the Environmental Scoping Document. This information has formed the basis of this environmental impact assessment, including the application of mitigation and management measures and the assessment of significance of residual impact.
5. Environmental offsets will be applied within a framework of adaptive management.	No offsets are proposed.
6. Environmental offsets will be focussed on longer-term strategic outcomes.	No offsets are proposed.

12.3 Assessment of significance of residual impacts

Table 67 provides an assessment of the residual impacts of the Proposal based on the residual impact significance model. Table 67 demonstrates the application of the mitigation hierarchy to the Proposal's preliminary key factors of flora and vegetation, terrestrial fauna, and subterranean fauna. The Proposal is not anticipated to result in any significant residual impact to potentially threatened species and ecosystems, areas of high environmental value or result in cumulative impacts reaching critical levels if not managed. In comparison to the principles of the Offset Guidelines the Proposal:

- Will not result in removal of Declared Rare Flora or buffers providing ecological function. The Proposal has been designed to avoid or minimise footprint impacts on 14 Priority Flora species and would not result in a species being listed as rare under the WC Act or listed as threatened under the EPBC Act
- Will not result in an ecological community being declared as environmentally sensitive under the EP Act or listed as a threatened ecological community under the EPBC Act. Clearing has been designed to ensure direct impacts to only 3.76% of the Violet Range PEC (Disturbance Footprint) with possible indirect impacts up to 5.24% (Development Envelope).
- Will not result in impacts to landscapes where the existing vegetation is required to maintain ecosystem services or where the impact causes a high degree of fragmentation. Fourteen Land Systems present within the Study Area all represent less than 1% of what exists in the broader north-eastern Goldfields region and are well represented specifically within the Eastern Murchison biogeographic region.
- Will result in clearing of vegetation within Jones Creek for creek crossing construction being kept to the minimum necessary for development (1.4% of existing Eucalyptus dominated ephemeral drainage line habitat within the Proposal study area) and would not result in significant residual impacts to watercourse or wetland dependent native vegetation.
- Will not result in impacts to ecological linkages between the Wanjarri Nature Reserve and the Violet Range PEC. No direct impacts on the Wanjarri Nature Reserve, or its connectivity to other conservation areas in the region, will occur.
- Will not result in impacts to communities or species that are representative of high biodiversity, have a higher diversity than other examples of an ecological community in a bioregion, or which is in "degraded" condition yet is in a better condition than other vegetation of the same community in the local area.

- Will not result in impacts that contribute to a terrestrial species being listed as specially protected under the WC Act or listed as threatened under the EPBC Act or where impact affects significant habitat for the species.

While the vegetation of the Study Area plays a role in providing fauna habitat, none of the Vegetation Associations that are significantly impacted in development of the Proposal are known to provide habitat critical to the maintenance of fauna species. Despite significant fauna survey efforts, no conservation significant terrestrial vertebrate species have been definitively identified within the Development Envelope. Furthermore, the available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of conservation significant species. The adjacent Wanjarri Nature Reserve is protected given the ecological values and biodiversity context of the reserve. The Development Envelope was also reduced from the original Yakabindie Proposal of up to 5,000 ha to the currently proposed 1,259 ha, a 75% reduction and will ensure protection of areas of higher biodiversity, priority flora, priority ecological communities, and riparian associated vegetation.

Clearing will necessitate the removal of some vertebrate and SRE invertebrate faunal habitat. One Confirmed, one Likely and 14 Potential SRE species have been collected from within the Development Envelope. All species collected within the Development Envelope for the Proposal have also been collected outside this area, meaning that no single species is restricted to the Development Envelope. Clearing in habitats with potential to support SRE has been minimised and will not result in significant residual impacts.

In conclusion, the significance of the residual impacts for these factors are not considered to require an offset position and accordingly no offsets are proposed.

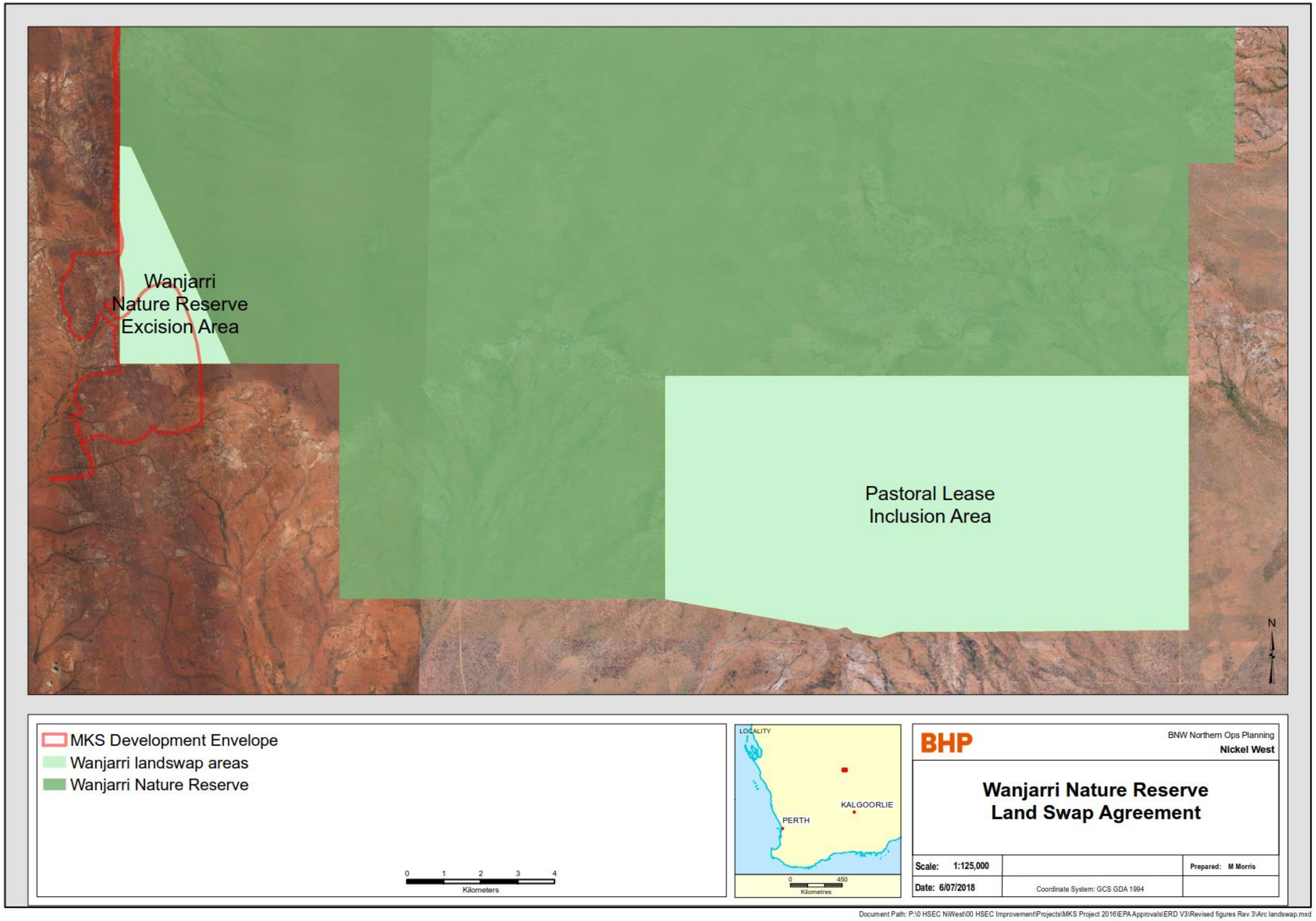


Figure 73 Wanjarri Nature Reserve Land Swap Agreement

Table 67 Significance of Residual Impacts

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
Clearing of native vegetation									
Clearing of up to 878ha of native vegetation	**Avoid:** In the development of this Proposal, the Development Envelope was reduced from the original Yakabindie Proposal of up to 5000 ha to the currently proposed 1,259 ha, a 75% reduction.	Waste dumps and general disturbance areas to be rehabilitated Six Mile Well pit will be backfilled and rehabilitated.	The MKS tenements have been extensively explored in the past and post exploration rehabilitation is found to have been largely effective. Vegetation condition outside the areas directly impacted by exploration and track maintenance is considered as being in Pristine condition with little evidence of pastoral activities. Areas having been disturbed in previous exploration works are regarded as being in Excellent condition while completely cleared areas were recorded as Completely Degraded (Western Botanical, 2017).	**Quality:** The majority of the Study area is considered in Pristine or excellent condition. It is considered likely that rehabilitation will successfully achieve a vegetation condition comparable to pre-disturbance. **Conservation Significance:** 3.76% of the Violet Range PEC is impacted by the disturbance footprint. 0.65% of the Violet Range PEC will remain un- rehabilitated. The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** The residual impact of clearing will not result in a significant area of disturbance to the Violet Ranges PEC and the majority of the disturbance will be rehabilitated. No impacts on flora and vegetation of the Wanjarri Nature Reserve will occur.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Loss of Priority flora and vegetation	**Avoid:** The Proposal has been designed to avoid five of 14 Priority Flora species and will not result in the	Future development of the Mine Closure Plan	As above	**Quality:** The majority of the Study area is considered in Pristine or excellent condition.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	upgrading of the Conservation Status of any of these Priority Species. **Minimise:** The section of haul road traversing a breakaway landform was deviated and narrowed to avoid and reduce impact to individuals of the P2 flora *Hibbertia sp. Sherwood Breakaways*. Dust suppression, including use of water carts on access roads, to be used during construction, operation and closure activities	will investigate suitability of using Priority flora in revegetation programs.		**Conservation Significance:** Clearing will necessitate the removal of a number of Priority plants from the Disturbance Footprint. Minor disturbance to Jones Creek will occur in the formation of two creek crossings. The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** Impacts to nine priority flora (1 P1, 1 P2, 5 P3 and 2 P4) will in the majority of instances be proportionally minor to the existing known populations. Monitoring and rehabilitation measures are targeted to ensure mitigation of indirect impacts. The residual impact to Priority flora will not result in change to Priority species status. Indirect impacts will be monitored through the Vegetation and Flora Management Plan.					
Loss of vegetation units from Violet Range PEC	**Avoid:** Clearing has been designed to ensure direct impacts to only 3.76% of the Violet Range PEC (Disturbance Footprint) with possible indirect impacts up to 5.24% (Development Envelope). Monitoring will be undertaken to assess any indirect impacts to the PEC and certain Priority species.	Seed collection of local provenance seed for use in rehabilitation	As above	**Quality:** The majority of the Study area is considered in Pristine or excellent condition. It is considered likely that rehabilitation will successfully achieve a vegetation condition comparable to pre-disturbance. **Conservation Significance:**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
				3.76% of the Violet Range PEC is impacted by the disturbance footprint. 0.65% of the Violet Range PEC will remain un- rehabilitated. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** Substantial proportions of all vegetation units that occur within the development envelope are not impacted by the Proposal. These will be a source of recruitment and seed that is used in revegetation programs. The impact to PEC vegetation communities that are not able to be rehabilitated, is 125 ha, which represents 0.35% of the Violet Range PEC.					
Spread of weeds	**Minimise:** Continued biannual weed monitoring and targeted spraying program to minimise existing weed populations and reduce potential spread to the Proposal via transport route. Implement biannual weed monitoring and targeted spraying program following completion of land clearing activities and during operations and closure activities.	Rehabilitation and revegetation of all but 125 ha of the PEC disturbance will be undertaken	As above	**Quality:** Six weed species are known from scattered populations in low numbers. The majority of the Study area is considered in Pristine or excellent condition. **Conservation Significance:** The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Monitoring and management of weeds will be undertaken during operations consistent with the Flora and Vegetation Management Plan.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
				Rehabilitation will be undertaken as specified in Mine Closure Plans. **Residual impact not considered to be significant because:** Weed monitoring and management is considered effective to mitigate risk of weeds and forms part of the Vegetation and Flora Management Plan.					
Loss and fragmentation of conservation significant fauna habitat (Mallee fowl, Black-flanked Rock Wallaby)	**Avoid:** No direct impacts on the Wanjarri Nature Reserve will occur. In the development of this Proposal, the Development Envelope was reduced from the original Yakabindie Proposal of up to 5000 ha to the currently proposed 1,259 ha, a 75% reduction. Section of haul road traversing a breakaway landform deviated and narrowed to avoid and reduce impact to Sherwood Breakaways habitat and Areas of Internal Drainage - Mulga habitat. **Minimise:** Land disturbance, including within Jones Creek for creek crossing construction, kept to a minimum for what is necessary for development of the Proposal within the design footprint.	Rehabilitation and revegetation of all but 125 ha of the disturbance footprint will be undertaken.	As above	**Quality:** Habitat is considered suitable to support malleefowl. Black-flanked Rock Wallaby habitat is marginal and considered non-core. Prevalence of superior quality habitat elsewhere in the region. **Conservation Significance:** No conservation significant species were recorded during surveys. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans. **Residual impact not considered to be significant because:** Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. None of the Vegetation Associations that are impacted by the Proposal are known to provide habitat critical to the maintenance of fauna species.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Loss and fragmentation	**Avoid**	Rehabilitation and	As above	**Quality**:	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
of potential habitat for SREs (of which one confirmed, one Likely and 14 Potential SRE species have been collected from within the Development Envelope)	Disturbance footprint designed to reduce disturbance to fauna habitats. **Minimise** Land disturbance within Jones Creek for creek crossing construction, kept to minimum necessary for development of the Proposal within the design footprint.	revegetation of all but 125 ha of the disturbance footprint will be undertaken.		Riparian vegetation is assessed to be in pristine condition. **Conservation Significance:** The Creek line and Internal Drainage habitats have a high potential of supporting SRE species (Figure 38). Approximately 4.5% of Creek line and 14.6% of Internal Drainage habitat within the Study Area will be directly impacted upon by the Proposal. From the Baseline and Targeted surveys, it is known that additional Creek line habitat and Internal Drainage habitat occurs outside of the Study Area and will not be directly impacted by the Proposal **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans. **Residual impact not considered to be significant because:** The proposed development has been designed to minimise impacts to the eucalypt dominated ephemeral drainage line of Jones Creek, which is considered to be the most significant of habitats from a short-range endemic fauna utilization and refuge perspective. The impact on the riparian vegetation is restricted to two creek crossings, with remaining riparian vegetation undisturbed. The residual impact to riparian vegetation is considered to be minor.					
Road crossing over Jones Creek									
Loss of riparian vegetation	**Avoid:** The Six Mile Well pit footprint will not directly impact Jones Creek.	Rehabilitation and revegetation	As above	**Quality:** Riparian vegetation is assessed to be in pristine condition.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
	Minimise: Land disturbance to Eucalyptus dominated ephemeral drainage line habitat within Jones Creek for creek crossing construction, kept to minimum necessary for development (1.4% of existing habitat within envelope). Road design for haul route to include the following control measures: <u>Breakaways</u> - Grading exposes clay saprolite which may be to prone to erosion. Competent rock cladding of erosive material (clay saprolite) exposed in cuttings and in table drains on steeper sections, particularly within breakaways. <u>Long slope-parallel sections</u> - Erosion in the lateral table drain. Adequately close spacing of diversion drains. <u>Oblique floodway crossings</u> - Roadway capturing drainage. Additional sub-basecourse fill to raise the road profile on the down-slope size of the floodway. <u>Contour-parallel sections</u> - Vegetation “shadowing”. Eliminate windrows in areas where overland flow needs to be maintained including swales, floodways (specific drainage features) and other areas where vegetation appears to be enhanced by overland flow perpendicular to the roadway.	of all but 125 ha of the disturbance footprint will be undertaken.		**Conservation Significance:** The Drainage Line Eucalypt Woodland comprises 50.46 ha of the Study Area, of which 1.67 ha will be disturbed. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** Minor disturbance (1.4%) to Eucalyptus dominated ephemeral drainage line habitat within Jones Creek will occur in the formation of two creek crossings. This disturbance will be rehabilitated on closure.					
Loss of creekline habitat in Jones Creek due to construction of	**Minimise:** Land disturbance within Jones Creek for creek crossing construction, kept to a minimum of what is necessary for development of the Proposal within the design	Rehabilitation and revegetation of all but 125 ha of the disturbance	As above	**Quality:** The Drainage Line Eucalypt Woodland condition is assessed as pristine. **Conservation Significance:**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
two creek crossing.	footprint. The impact on the riparian vegetation is restricted to creek crossings, with remaining riparian vegetation undisturbed.	footprint will be undertaken.		The Drainage Line Eucalypt Woodland, of which 1.67 ha will be disturbed, represents potential habitat for short range endemics. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** The impact on the riparian vegetation is restricted to creek crossings, with remaining riparian vegetation undisturbed. The residual impact to riparian vegetation is considered to be minor.					
Dewatering and groundwater abstraction									
Drawdown impact on vegetation	**Minimise:** Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline. Limit groundwater abstraction for Proposal water supply to pit dewatering, and existing NMK water supply (borefields and stormwater harvesting).	Groundwater modelling shows that drawdown of 5 metres will extend up to several hundred metres beyond the pit crest. In the baseline condition minor aquifers are typically submerged (confined) by 20 metres such that, at maximum Proposal drawdown, they will remain fully	Surface vegetation is not considered to be groundwater dependent due to depth to water table and will not be affected by either dewatering of post-closure potential rise in water table of 0.6m above baseline.	**Quality:** The Drainage Line Eucalypt Woodland condition is assessed as pristine. **Conservation Significance:** The Drainage Line Eucalypt Woodland comprises 50 ha of the Study area. The priority species *Hemigenia exilis* (P4) has been recorded within this vegetation community. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Rehabilitation will be undertaken as specified in Mine Closure Plans **Residual impact not considered to be significant because:** Surface vegetation is not considered to be groundwater dependent due to depth to water table and will not be affected by	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
		saturated, and hence practically un-impacted, well within the 5-metre drawdown contour extent. Groundwater mounding is not considered to be a significant residual impact.		either dewatering of post-closure potential rise in water table of 0.6m above baseline.					
Loss of subterranean fauna habitat	Minimise: Minimisation measures are limited by the location of the ore body. Dewatering will be limited to that which is required for operations to proceed. The proposed mining areas are well defined so will ensure only target areas will be disturbed, thereby limiting impact area.	Upon completion of mining, the Six Mile Well pit will be backfilled and will not be subject to evaporation losses such that groundwater levels will recover, at least to the baseline water table level (503m AHD).	The distributions and genetic diversity exhibited by *Atopobathynella* sp. OES8 and *Atopobathynella* sp. OES11 do support the hydrogeological information that the habitable portion of the Six Mile Well regolith aquifer system is hydraulically connected to a network of other regolith and fractured rock aquifers associated with the upper Jones Creek catchment. The distribution of	**Quality:** Areas of impact associated with the development of Goliath and Six Mile Well pits are not recognised as hosting high biological values or representative of high biodiversity. The Study Area was found to host a troglofauna assemblage of very low species richness and abundance. No troglofauna were recorded from within the Development Envelope. **Conservation Significance:** No threatened or priority subterranean fauna species have been identified within the Study Area. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Dewatering will occur progressively with mining.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
			Atopobathynella sp. OES8 demonstrates that the hydraulic network extends at least to the non-impact zones within the Goliath Proposal Area. The possibility also exists that the network extends further south along Jones Creek and associated main tributaries.	**Residual impact not considered to be significant because:** The Proposal is considered not to pose a risk to the long-term survival of any known troglofauna species, as no species were collected from within the proposed impact areas. The two stygobitic species recorded from within the proposal area have broader distributions. The development of the Six Mile Well and Goliath pits and associated dewatering is considered not to pose a long term conservation risk to stygofauna.					
Reduced catchment flow and yield within Jones Creek	**Avoid** The Six Mile Well pit footprint will not directly impact Jones Creek. **Minimise** Design of single large waste rock landform minimises footprint and impact on catchment. Oblique floodway crossings - Roadway capturing drainage. Additional sub-basecourse fill to raise the road profile on the down-slope size of the floodway. Contour-parallel sections - Vegetation "shadowing". Eliminate windrows in areas where overland flow needs to be maintained including swales, floodways (specific drainage features) and other areas where vegetation appears to be enhanced by overland flow perpendicular to the roadway	Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan	Rehabilitated landscape likely to return flows to pre-mining flows.	**Quality:** The Proposal is located in the upper catchment of Jones Creek, an ephemeral water course. The baseline water quality in the Jones Creek system is characterised as circumneutral to alkaline, freshwater, with low turbidity (except in the claypans), and variable nutrients. Metals (such as nickel and zinc), are typically present in low concentrations, with the exception of aluminium and copper which are known to exceed the ANZECC (2000) 80% species protection trigger values for freshwater in both the creek and claypans. **Conservation Significance:** Jones Creek drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to several claypans near the valley axis. Minor flows of several hours duration typically occur one to three times per year. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
				Time Scale: Catchment yield reduction primarily limited to operations phase. Rehabilitated landscape likely to return flows to pre-mining flows. **Residual impact not considered to be significant because:** Modelling has determined that catchment scale reduction in flow volume to be minor. Flow frequency and duration will be practically unaffected and total catchment discharge reduction will be approximately proportional to the catchment area reduction. Modelling shows that in most years that large scale catchment-wide flow occurs, the total annual yield greatly exceeds the capacity of the terminal Claypan such that the frequency of filling the Claypan will be barely diminished by the development.					
Mining activities – all phases									
Indirect dust impacts on vegetation within the adjacent Wanjarri Nature Reserve	**Minimise:** Dust suppression, including use of water carts on access roads, to be implemented during all Proposal phases.	Potential impacts will cease once mining and closure activities are complete.	Impacts limited to duration of site activities.	**Quality:** The majority of the Study area is considered in Pristine or excellent condition. **Conservation Significance:** 3.76% of the Violet Range PEC is impacted by the disturbance footprint. The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Dust suppression will be undertaken during the operations phase. **Residual impact not considered to be significant because:**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
				Dust modelling indicates that even without dust suppression, particularly on the haul road, predicted dust concentrations are below the nominated standards at all discrete receptors, including within Wanjarri Nature Reserve. Dust management measures are expected to prevent impacts to vegetation health.					
Vehicle strikes	**Minimise:** Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas Designated speed limits on access and haul roads to reduce fauna strikes.	Potential impacts will cease once mining and closure activities are complete.	Impacts limited to duration of site activities.	**Quality:** Habitat is considered suitable to support malleefowl. Black-flanked Rock Wallaby habitat is marginal and considered non-core. Prevalence of superior quality habitat elsewhere in the region. The Wanjarri Nature Reserve is located directly east of the Proposal. **Conservation Significance:** No conservation significant species were recorded during surveys. The likelihood of conservation significant fauna interaction is low. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Vehicle movements shall be undertaken during the operations phase. **Residual impact not considered to be significant because:** Noise and vibration emissions from machinery and vehicles may assist to deter some species from transportation routes. Ground-dwelling species are at greatest risk of vehicle strike. The overall risk to vertebrate fauna is low and unlikely to result in a change of conservation status.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Noise and vibration, light	**Minimise:**	Potential impacts will cease once	Impacts limited to duration of site activities.	**Quality:**	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
emissions impacts	Lighting designed to illuminate designated operations areas rather than the surrounding landscape.	mining and closure activities are complete.		Amenity values can be highly subjective, with different levels of perception or tolerance of impacts. **Conservation Significance:** The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Noise, vibration and light emissions will occur throughout the operations phase. **Residual impact not considered to be significant because:** The residual impacts of the Proposal on the amenity values of Wanjarri Nature Reserve are minor and, with the exception of visibility of the final waste rock landform, can be mitigated with appropriate management measures.					
Increase in feral animals	**Minimise:** Putrescible wastes associated with site offices to be stored in bins with lids and transferred to Mt Keith operations for disposal. Policy prohibiting feeding of native animals. Designated speed limits on access and haul roads to reduce fauna strikes. Removal of dead fauna away from edges of roads.	Potential impacts will cease once mining and closure activities are complete.	Impacts limited to duration of site activities.	**Quality:** Spread of feral animals and weeds through increased human activity and disturbance could result in changes to species composition, fire frequency and abundance of native communities. **Conservation Significance:** The Wanjarri Nature Reserve is located directly east of the Proposal. **Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Attraction of feral animals is a risk during the operations phase.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
				Residual impact not considered to be significant because: Management measures to minimise feral animal attraction include removal of dead fauna away from edges of roads, storing food wastes in lidded bins and restrictions on feeding animals. These are considered appropriate to reduce feral animal risk.					
Harm to fauna accessing contaminated surface water, such as Jones Creek and pit lakes.	**Minimise:** Operations: - Segregation of clean and dirty stormwater is the primary mitigation measure to protect local surface water quality. Stormwater diversion away from mining infrastructure and capture and treatment of contaminated stormwater will be implemented. Post closure construction of abandonment bund and perimeter stock fencing around the final Goliath pit void and construction of bund across the top of pit access ramps and suitable egress point for fauna and stock (in the event abandonment bunds and fences are breached). Post closure diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks.	Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan. In particular, backfilling of the Six Mile Well Pit will allow full recovery of groundwater levels.	The likelihood of access to the water is low due to the inherent depth to water and if access were possible, studies undertaken for the Mt Keith Closure Plan (Nickel West, 2017) indicate that once the pit lake water becomes hypersaline, fauna will not drink the water. This risk will be mitigated by the construction of an abandonment bund and perimeter stock fencing around the final void. Other controls will include construction of bund across the top of pit access ramps to deter stock (cattle), fauna and human access (in the event abandonment	**Quality:** The Proposal is located in the upper catchment of Jones Creek, an ephemeral water course. The baseline water quality in the Jones Creek system is characterised as circumneutral to alkaline, freshwater, with low turbidity (except in the claypans), and variable nutrients. Metals (such as nickel and zinc), are typically present in low concentrations, with the exception of aluminium and copper which are known to exceed the ANZECC (2000) 80% species protection trigger values for freshwater in both the creek and claypans. After closure, the Goliath pit will partially refill to form a very deep pit lake and minor discharge zone from the generally impermeable country rock. Lake water will initially reflect the chemistry of groundwater, being brackish and with low levels of trace components except for slightly elevated boron. **Conservation Significance:** Jones Creek drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to several claypans near the valley axis. Minor flows of several hours duration typically occur one to three times per year. There is a risk pit lakes may attract native fauna.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Existing Environmental Impact	Mitigation			Significant residual impact	Offset Calculation Methodology				
	Avoid and minimise	Rehabilitation type	Likely rehabilitation success		Type	Risk	Likely offset success	Time Lag	Offset Quantification
			bunds and fences are breached) and diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks.	**Land Tenure:** The Proposal sits within the Yakabindie pastoral lease and mining tenements. **Time Scale:** Risks to surface water quality of Jones Creek primarily occur during construction and operations. Risks associated with pit lakes occur post closure. **Residual impact not considered to be significant because:** The residual impacts of the Proposal on surface water, including the formation of pit lakes, are not considered to be significant and can be managed through the implementation of the proposed mitigation measures. In particular regarding pit lakes, the likelihood of access to the water is low due to the inherent depth to water and if access were possible, studies undertaken for the Mt Keith Closure Plan (Nickel West, 2017) indicate that once the pit lake water becomes hypersaline, fauna will not drink the water.					
Sedimentation and/or contamination of Jones Creek and drainage lines as a result of mining activities.	**Avoid** Landforms designed to lie outside of flood impact zones. **Minimise** Operations: - Segregation of clean and dirty stormwater is the primary mitigation measure to protect local surface water quality. Stormwater diversion away from mining infrastructure and capture and treatment of contaminated stormwater will be implemented.	Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan	Impacts limited to duration of site activities.		Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

13 Holistic Impact Assessment

The EIA process needs to consider the connections and interactions between parts of the environment to inform a holistic view of impacts to the whole environment. This requires consideration of the impacts of the Proposal in a regional context as well as at the local scale.

The Proposal is intended to operate as a satellite mine, providing ore to the Mt Keith Nickel Operations and ultimately feed to the Kalgoorlie nickel smelter. All ore processing is undertaken as part of the existing NMK under existing approvals for that site. As the ore supplied to Mt Keith by the Proposal is intended to replace existing supply as it winds down, no significant additional impacts have been predicted for the existing Mt Keith operations (e.g. tailings volumes, workforce accommodation and associated infrastructure, waste disposal etc.).

In a regional context, as shown in Figure 1, the Proposal is one of a number of nickel mines following the regional geology of generally narrow linear belts of greenstone sequences. The dominating underlying geology/regolith strongly influences the vegetation association species composition (Section 5), some of which are constrained within the Perseverance fault line and within the boundaries of the Violet Ranges Priority Ecological Community. While narrow in an east-west orientation, these landforms extend for over 80 km in a north-south orientation.

The Study Area lies approximately centrally within the *Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation)* Priority 1 PEC which extends for approximately 32 km in a north-south orientation and approximately 11 km in an east-west orientation at its widest point (Figure 11). The proposed Development Envelope represents 5.87 % of the Violet Ranges PEC as currently mapped. Minimal historical impacts to the Violet Ranges PEC have occurred to date with clearing for pastoral tracks and fences as well as historical mining activities at the decommissioned Bellevue mine site on the north-shore of Lake Miranda being the major contributors.

The environmental studies commissioned for this Proposal (flora and vegetation, terrestrial fauna (including targeted surveys), SRE terrestrial fauna, stygofauna, surface and groundwater hydrology, air quality, noise, Aboriginal heritage) have considered and assessed potential Proposal impacts both at a local and regional scale in the context of the local and regional geology and biogeography. The results of these studies have informed the Proposal impact assessment and development of mitigation measures.

Table 68 provides a discussion of the predicted outcomes in relation to the environmental principles of the EP Act.

The interconnected nature of the environmental factors and potential impacts arising from mining activities is demonstrated in Table 69.

Table 70 provides a summary of the impact assessment and predicted outcomes of the Proposal in relation to the EPA's objectives for each factor.

NiW considers the potential impacts for the preliminary key environmental factors can be appropriately managed through the implementation of specific mitigation measures. Management plans applicable to the implementation of this Proposal include:

- Vegetation and Flora Environmental Management Plan;
- Hydrological Processes Environmental Management Plan; and
- Mt Keith Satellite Proposal Mine Closure Plan.

Table 68 Environmental Principles and Proposal Predicted Outcomes

Environmental Principles	Predicted Outcomes
1 The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by: a. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b. an assessment of the risk-weighted consequences of various options	The proposal will require clearing of up to 878 ha within a Development envelope of 1259 ha. The Disturbance Footprint has been minimised as far as possible to reduce the area of vegetation required to be cleared. Aspects of the Disturbance Footprint, such as the haul road, have been further modified to avoid impact on aspects of the environment that have local and regional importance in terms of flora and vegetation, fauna habitat, stream flow and Aboriginal heritage. Furthermore, all disturbed areas, with the exception of the Goliath Pit, are planned to be rehabilitated. Of the 878 ha of clearing, 753 ha will be rehabilitated (85.8% of total area cleared). The Proposal lies within the Violet Ranges Priority 1 PEC and clearing will impact on less than 4% of the mapped area of this PEC (724.4 ha). Of the PEC disturbance area, 599ha will be rehabilitated (83%). The Goliath Pit, not subject to rehabilitation, represents 17% of the total area of the PEC.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	There are no Threatened (Declared) Rare flora or Threatened Ecological Communities within the Development Envelope or wider Study Area. None of the faunal habitats are restricted to the Study Area.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	The Study Area has been subject to extensive surveys. Further targeted surveys were undertaken for this Proposal for conservation significant flora and fauna species known or considered to occur within the Study Area. The Proposal is known to support 14 Priority Flora species and has been designed to minimise impacts on these and will not result in the upgrading of the Conservation Status of any of these Priority Species. The results of the surveys undertaken as part of the assessment of this Proposal, as provided to DBCA and the WA Herbarium, have resulted in the revision of the priority status of two species from P1 to P2 (*Eremophila* sp. long pedicals, *Hibbertia* sp. Sherwood Breakaways). A number of conservation significant species have been recorded in the vicinity of the Development Envelope (e.g. Night Parrot, Black-footed Rock-wallaby, Mallee Fowl). Recent survey efforts did not record any of these species in the Development Envelope or the wider Study Area. A risk assessment of potential impacts was undertaken based on known distribution, records from within the Study Area, suitable habitat and likelihood of occurrence. In all cases for Priority species that may occur within the Development Envelope, the risk have been assessed as low. The proposed Project is considered to not pose a risk to the long-term survival of any known troglofauna species as no species were collected from the within the proposed impact areas. In addition, the distributions of potentially undetected troglomorphic species are unlikely to be restricted to small areas such as the proposed impact areas because of the continuity and extent of habitat present. The stygofauna assemblage present are sparsely distributed in a dendritic nature reflecting the network of habitable regolith, alluvial and fractured groundwater systems present, that appear to be closely associated with Jones Creek and tributaries Despite efforts to avoid or minimise impacts on Aboriginal heritage sites, the Proposal may have a residual impact on twenty-three known places within the area for which s 18 consent was obtained in 2003. The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. Some restrictions to access will be required during the construction and operation of the mine, this will include isolated minor changes to access country to hunt and gather. NiW intends to work together with the Tjiwarl

Environmental Principles	Predicted Outcomes
	People to manage cultural heritage within the Proposal area. To further this goal a CHMP will be developed and will address appropriate contingency actions The proposal lies adjacent to the western boundary of the Wanjarri Nature Reserve, being the only conservation reserve in the northern part of the eastern goldfields. This arid zone conservation reserve was formerly a small pastoral lease. In 2011, NiW entered into a land swap agreement with the Government of Western Australia to create a mining reserve for the future mining of associated with the Proposal. This land swap involved an excision area comprised of 1.4 per cent of the total area of the Wanjarri Nature Reserve, and an inclusion area being 10 times the size of the excision area with significant conservation values. This land swap was legislated in the *Reserves (Wanjarri Nature Reserve) Act 2012.* The Proposal will not directly impact on the Reserve. The key residual indirect impact will be the visibility of the final WRL on route to the Reserve, but with no or limited visibility within the Reserve itself. Mining activities will not prevent or impact on the recreational or conservation values of the Reserve. The ERD demonstrates that clearing will not have a significant impact at either a local or regional scale, through the implementation of appropriate mitigation measures. An additional mitigating factor is the proximity of the Wanjarri Nature Reserve which provides an important arid zone conservation reserve, protecting local and regionally significant elements of geology, biogeography, and Aboriginal and European heritage.
4. Principles relating to improved valuation, pricing and incentive mechanisms a. Environmental factors should be included in the valuation of assets and services. b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	In the development of this Proposal, the Development Envelope was reduced from the original Yakabindie Proposal of up to 5000 ha to the currently proposed 1,259 ha, a 75% reduction. Whilst environmental factors were a driving force for change, consideration was also given to better utilisation of existing resources at the Mt Keith operations (processing, tailings and waste disposal and ancillary facilities). The new MKS Proposal significantly reduced the cost and footprint of the development of the Yakabindie resource whilst maintain economic viability. NiW has recently undertaken a two year study to determine the optimal closure plan for Mt Keith and all other NiW sites. This study addressed a number of concern raised by DMIRS regarding NiW's mine closure planning and moved emphasis to provision of basis of, and details of capital works program to be completed at mine closure. This has culminated in the submission of an overall Mt Keith Mine Closure Plan (MCP) and the preparation of the MKS Mine Closure Plan, which is subsidiary to the overall Mt Keith MCP. The MCP's describe progressive activities pre-closure and the post closure execution monitoring and maintenance program (to verify the success of closure activities) as part of a staged, credible path to relinquishment of mining tenements and residual liabilities.
5. The principle of waste minimisation. All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	The MKS Proposal will provide ore to the Mt Keith processing facility as the current ore supply from Mt Keith Mine winds down. This will enable continuity in ore production and also waste management. The ore processing waste stream will essentially not change. Minor volumes of MKS site waste (putrescible and other) will be generated by the ancillary office and laydown area at the Satellite site and require treatment and disposal. This is planned to be managed at the existing Mt Keith waste facilities within current licensed capacity, to avoid duplication of facilities. Waste rock from the MKS Proposal will in the long term be used to backfill the Six Mile Well pit to produce a "flat" ground level site for rehabilitation. The remaining WRL will be revegetated.

Table 69 Interconnection of environmental factors and potential impacts of proposed mining activities

	Environmental Factors						
	Flora and Vegetation	Terrestrial Fauna, including SRE Fauna	Subterranean Fauna	Hydrological processes	Inland Waters Quality	Social Surroundings	
						Aboriginal Heritage	Wanjarri Nature Reserve Visual and recreational amenity
Proposal Activities	**Potential Impacts**						
Clearing of native vegetation	Clearing of up to 878ha of native vegetation Loss of Priority flora and vegetation Loss of vegetation units from Violet Range PEC Spread of weeds Loss of native seedbank Altered fire regime	Loss of conservation significant fauna habitat (Mallee fowl, Black-flanked Rock Wallaby) Habitat fragmentation / disruption to linkages		Alteration of surface flows and pools	Change in surface water quality (e.g. sedimentation)	Loss or disturbance to Aboriginal heritage sites	Impacts on adjacent vegetation (e.g. dust)
Road crossings over Jones creek	Loss of riparian vegetation	Disturbance to (including migratory species)		Alteration to surface flows and pools	Change in surface water quality (e.g. sedimentation)	Disturbance to culturally significant landscape feature	
Dewatering	Drawdown impact on vegetation		Direct mortality Loss of habitat	Altered groundwater regimes	Changes in groundwater quality		
Groundwater abstraction for water supply	Drawdown impact on vegetation		Direct mortality Loss of habitat	Altered groundwater regimes	Changes in groundwater quality		
Mining activities - all phases (operation of heavy and light vehicles, mining equipment, blasting, waste disposal)	Dust impacts on vegetation	Vehicle strike Noise and vibration, light emissions impacts Increase in feral animals		Alteration to surface water flow	Change in surface water quality (e.g. contaminated, runoff) Changes in groundwater quality	Temporary/permanent constraints on traditional cultural activities Prevention or change in access to Aboriginal site	Change in access to Reserve Impacts of dust, noise, vibration, light emissions on recreational values
Physical mining landforms (WRL, ROM pad, pits, ancillary infrastructure area, roads)		Harm to fauna accessing contaminated surface water (including pit lakes)		Groundwater mounding	Changes in groundwater quality (from pit lakes) Change in surface water quality (e.g. contaminated runoff)	Temporary/permanent constraints on traditional cultural activities Prevention or change in access to Aboriginal site	Changes in visual aesthetics Change in access to Reserve
Surface water diversions and drainage				Alteration to surface water flow		Impact to Jones Creek	

Table 70 Summary of Environmental Impact Assessment for Key Environmental Factors

Environmental Factor: Flora and Vegetation		**EPA Objective:** To protect flora and vegetation so that biological diversity and ecological integrity are maintained	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The Study Area is located within the eastern portion of the Murchison Biogeographic Region and the East Murchison (MUR1) subregion. No Threatened (Declared Rare) flora is known within the Study Area. Fourteen Priority flora are known within the Study Area (one P1, two P2, eight P3 and three P4 species). The majority of species known from the overall Study Area are both common and widespread in the eastern Murchison, western Great Victoria Desert biogeographic regions. No Threatened Ecological Community (TEC) is known within the Study Area. The Study Area lies approximately centrally within the Violet Ranges (Perseverance Greenstone Belt) vegetation complexes (banded ironstone formation) Priority 1 Priority Ecological Community.	Clearing of up to 878 ha within Development Envelope of 1259 ha. Loss of native vegetation communities. Loss of Priority flora. Loss and/or fragmentation of vegetation communities, particularly those of the Violet Range PEC, Wanjarri Nature Reserve and conservation significant species. Altered fire regime and associated change and/or loss of vegetation. Dust from mining activities resulting in reduced health and condition or loss of significant flora, including vegetation within Wanjarri Nature Reserve. Mining activities resulting in increased spread of weeds and potential for cumulative impacts such as altered fire regimes	**Avoid** Disturbance footprint designed to reduce disturbance to Priority flora. Vegetation clearing to be limited to Proposal Disturbance Footprint, with no clearing or mining activities to occur within Wanjarri Nature Reserve Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to individuals of the P2 flora Hibbertia sp. Sherwood Breakaways. Waste Rock Landform design will avoid direct impact to individual *Hibiscus krichauffianus* (P3) **Minimise** Land disturbance kept to minimum necessary for development of the Proposal within the design footprint. Existing internal ground disturbance procedures and permitting system will be implemented ("Environmental and Heritage Impact Approval" process). Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. Dust suppression, including use of water carts on access roads, to be used during construction, operation and closure activities. Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to MKS via transport route. Implement similar minimum biannual weed monitoring and targeted spraying program at MKS following completion of land clearing activities and during operations and closure activities. Firefighting equipment will be located on site and emergency personnel will be trained in fire response.	The following residual impacts are considered to be of minor significance at both local and regional scale: Clearing will necessitate the removal of a number of conservation significant plants from the Disturbance Footprint. Minor disturbance to Jones Creek will occur in the formation of two creek crossings. Remaining riparian vegetation will not be disturbed. Clearing will directly impact 3.76% of the Violet Range PEC (Disturbance Footprint) with possible indirect impacts up to 5.24% (Development Envelope). Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. No direct impacts on the Wanjarri Nature Reserve will occur. NiW considers that clearing required for the Proposal will not have significant residual impacts and meets the objective for this factor.

		A Hot Work Permit system will be implemented. All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. Proposal site induction to include information on prevention and management of fires. Clearing, topsoil stripping and stockpiling will be undertaken in accordance with NiW procedures. Undertake monitoring and adaptive management in accordance with the Flora and Vegetation Environmental Management Plan (Appendix C) **Rehabilitate** Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	
Environmental Factor: Terrestrial Fauna		**EPA Objective:** To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Eight terrestrial vertebrate fauna habitats were described for the Study Area based on vegetation mapping, geology, landform and soils. These include: Hills and Slopes, Sclerophyll Shrublands Undulating Plains, Sclerophyll Shrublands Drainage tract – Mulga Undulating Plains Grass Dominated Undulating Plains – Chenopod Shrublands Areas of Internal Drainage – Mulga Drainage Line Hills and Slopes, Chenopod Shrublands None of the fauna habitats are restricted to this area, based on the broader distribution of vegetation communities and land system types.	Clearing of native vegetation resulting in loss and/or fragmentation of faunal (terrestrial and SRE invertebrate) habitat altered fire regime and associated change and/or loss of vegetation; and loss of native seedbank Loss of creekline habitat in Jones Creek due to construction of two creek crossing Mining activities resulting in increased spread of weeds. Light, noise and vibration resulting in changes in faunal behaviour and community structure. Dust from mining activities resulting in reduced vegetation health and condition. Increase in sediment load to Jones Creek resulting in sedimentation downstream	**Avoid** Disturbance footprint designed to reduce disturbance to conservation significant flora. Vegetation clearing to be limited to Proposal Disturbance Footprint, with no clearing or mining activities to occur within Wanjarri Nature Reserve. Section of haul road traversing breakaway landform deviated and narrowed to avoid and reduce impact to Sherwood Breakaways habitat and Areas of Internal Drainage - Mulga habitat. **Minimise** Land disturbance, including within Jones Creek for creek crossing construction, kept to minimum necessary for development of the Proposal within the design footprint. Existing internal ground disturbance procedures and permitting system will be implemented. Vehicles and mining equipment access limited to designated roads/access tracks and cleared areas. Dust suppression, including use of water carts on access roads, to be implemented during all Proposal phases.	The following residual impacts are considered to be of minor significance at both local and regional scale. Clearing will necessitate the removal of some vertebrate and SRE invertebrate faunal habitat. Minor disturbance (1.4%) to Eucalyptus dominated ephemeral drainage line habitat within Jones Creek will occur in the formation of two creek crossings. Adjacent vegetation within the buffer of the Development Envelope should remain intact with little or no disturbance allowing ecosystem processes to continue both at local and regional scale. No direct impacts on the Wanjarri Nature Reserve will occur. While the vegetation of the Study Area plays a role in providing fauna habitat, none of the Vegetation Associations that are significantly impacted in development of the MKS Proposal are known to provide habitat critical to the maintenance of fauna species. The proposed development has been designed to minimise impacts to the eucalypt dominated ephemeral drainage line of Jones Creek, which is considered to be the most significant of habitats from a short-range endemic fauna utilization and refuge perspective. The impact on the riparian vegetation is

The 28 fauna survey sites within the Study Area have yielded 135 vertebrate species, comprising 17 mammals, 77 birds and three frogs. A number of conservation significant species have been recorded in the vicinity of the Development Envelope (e.g. Night Parrot, Black-footed Rock-wallaby, Mallee Fowl). Recent survey efforts did not record any of these species in the Development Envelope or the wider Study Area.		Lighting designed to illuminate designated operations areas rather than the surrounding landscape. Continued biannual weed monitoring and targeted spraying program at NMK to minimise existing weed populations and reduce potential spread to MKS via transport route. Implement biannual weed monitoring and targeted spraying program at MKS following completion of land clearing activities and during operations and closure activities. Firefighting equipment will be located on site and emergency personnel will be trained in fire response A Hot Work Permit system will be implemented. All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. Proposal site induction to include information on prevention and management of fires Putrescible waste materials to be stored in bins with lids and transferred to Mt Keith operations for disposal No feeding of native animals Designated speed limits on access and haul roads to reduce fauna strikes Removal of dead fauna away from edges of roads Mitigation actions for creek crossings within Jones Creek discussed in Section 8. **Rehabilitate** Waste dumps and general disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	restricted to creek crossings, with remaining riparian vegetation undisturbed and is considered to be minor. A risk assessment of potential impacts was undertaken based on known distribution, records from within the Study Area, suitable habitat and likelihood of occurrence. In all cases for Priority species that may occur within the Development Envelope, the risk have been assessed as low. The remaining available habitat in the region and proximity to protected habitat within the Wanjarri Nature Reserve reduces the risk of significant impact to local and regional populations of conservation significant vertebrate and SRE invertebrate species. NiW considers that the Proposal meets the objective for this factor.
Environmental Factor: Subterranean Fauna		**EPA Objective:** To protect subterranean fauna so that biological diversity and ecological integrity are maintained	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The geology of the Project area is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite,	Removal of habitat through excavation of the proposed mining pits, Goliath and Six Mile Well; and Drying out of habitat through the lowering of the groundwater table associated with mine pit dewatering.	**Avoid** Avoidance and minimisation measures to mitigate the impacts of mining excavation and associated groundwater drawdown on components of the subterranean fauna assemblage recorded are limited. Proposed mining areas are well defined that will insure	The proposed development of the Goliath and Six Mile Well pits are not considered to represent a significant residual impact to the stygofauna values recorded from parts of the Study Area. Under the residual impact significance model the proposed areas of impact associated with the development of Goliath and Six Mile Well pits are not

which host the nickel sulphide deposits (MWES Consulting 2017b). The Proposal is located within the upper catchment of the Jones Creek which is a lateral tributary system, incised into the Barr-Smith Range. The majority of runoff for this ephemeral water course is received from the upper catchment, which covers an area of 64.1 km2. In large flood events, water is rapidly shed from this part of the catchment into the creek, aided by the rocky nature of the terrain. The terminus for the creek is a large floodplain area to the south west, containing a number of claypans (MWES Consulting 2017b). Beyond this, drainage becomes increasingly diffuse, before encountering the Yakabindie calcrete and reaching Lake Miranda, located within the Carey Palaeodrainage system (Wetland Research and Management 2005) (Stantec, 2017b). This catchment lies within the larger catchment of an ancient river system, the Carey Palaeodrainage, which once flowed south east into the Eucla Basin. Major fresh and hypersaline aquifers are contained within the palaeodrainage ground waters. Groundwater resources within the Carey Palaeodrainage catchment include calcrete, fractured rock and unconfined regolith (alluvial and colluvial) aquifers, a number of which are important in maintaining local stygofauna assemblages (Outback Ecology 2008, 2012a, b, d, Subterranean Ecology 2011a, Wetland Research	Changes to groundwater quality and chemistry through increase in sediment load in run-off from mine associated activities into tributaries leading to reduction in surface to groundwater infiltration rates lessening influx of resources (e.g. nutrients, oxygen); and Contamination of groundwater by fuel spills.	only target areas will be disturbed, thereby limiting impact area to proposed limits. Goliath pit and the northern portion of the Six Mile Well pit were found to not host suitable subterranean fauna habitat. Dewatering will be limited to the extent that is required for mining to occur. Construction and maintenance of surface water drainage systems to control and contain run-off from mining areas and divert clean stormwater away from pits and other mining disturbance areas. Drainage alongside transportation corridor to control run-off and divert clean stormwater away from access ways and topsoil stockpiles. Fuel storage to be maintained with self bunded facilities. Hydrocarbon contaminated soil and materials to be removed for disposal or remediation Avoidance of Jones Creek riparian zone other than for creek crossings. **Rehabilitation** The specific rehabilitation of subterranean fauna habitat has not been attempted before and will not be attempted for the Goliath and Six Mile Well pits. Post cessation of mining, Six Mile Well pit will be completely backfilled so groundwater levels will return close to baseline levels in the long term. Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). **Likely Rehabilitation Success** It is not expected that the depauperate subterranean fauna environmental values would return within the backfilled pit area. However, outside of the backfilled mine pit within the groundwater drawdown impact zone, subterranean fauna environmental values are considered likely to recover with natural restoration of groundwater levels	recognised as hosting high biological values or representative of high biodiversity. In addition, the proposed impacts are not considered likely to result in any subterranean species being listed as specially protected or threatened. The proposed Project is considered to not pose a risk to the long-term survival of any known troglofauna species as no species were collected from the within the proposed impact areas. For stygofauna, the two stygobitic species, Atopobathynella sp. OES11 and Gomphodella sp. IK2, recorded from within proposed Six Mile Well groundwater drawdown impact areas only, are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The broader distributions of both species is supported by the wider distribution of *Atopobathynella* sp. OES8 and relatively high haplotype diversity of *Atopobathynella* sp. OES11. The development of the Six Mile Well and Goliath pits and associated dewatering is considered to not pose a long term conservation risk to stygofauna and that the EPA objective for this factor can be met. Nickel West considers that development of the Six Mile Well and Goliath pits and associated dewatering will not pose a long term conservation risk to stygofauna and that the EPA objective for this factor can be met.

and Management 2005). The greenstone landscape that dominates the Development Envelope is dissected by alluvial drainage lines (Stantec, 2017b). A number of stygofauna surveys have been undertaken in the area surrounding the Proposal (≤200 km), predominantly within calcrete associated groundwaters. Previous assessments have found that troglofauna do not represent a key environmental factor, and the focus of this assessment has therefore been on stygofauna species and habitat.			
Environmental Factor: Hydrological Processes		**EPA Objective:** To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
The Proposal is located within a semi-arid zone, where surface flows are ephemeral and groundwater is limited due to geology. The Proposal pits will intersect groundwater resources. The geology of the Proposal Area is generally a low porosity peridotite komatiite ultramafic located in the Archean Agnew-Wiluna greenstone belt with lozenges of adcumulate ultramafic or dunite, which host the nickel sulphide deposits Regionally the Proposal is located within the Lake Miranda catchment, and locally is located within the upper catchment of Jones Creek. The terminus for Jones Creek is a large floodplain area in the valley floor to the south west, containing a number of claypans.	Impacts to the natural surface water flow as a result of placement, design and operation of mine pits and associated infrastructure Impacts to surface water resources, including Jones Creek, from alterations to surface water flows and groundwater drawdown Impacts to subterranean fauna as a result of groundwater drawdown and mounding	**Avoid** The Six Mile Well pit footprint has been designed such that Jones creek diversion is not required. Proposed mine layout is designed to lie outside of the flood zones. Jones Creek crossings constructed to avoid impact to natural flows. **Minimise** Design of single large waste rock landform minimises footprint and impact on catchment. Construction of clean water diversion drains impose volumetric limits on stormwater by the disturbed area, and maintains catchment flow. Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. Peak flood flow exclusion bund constructed at pit perimeter. Undertake monitoring of groundwater levels in the vicinity of Six Mile Well pit to confirm predicted extent of	The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. For the large majority of creek flow events, there is no potential interaction between the flood water and proposed major landforms (pits and dump). The potential for interaction only occurs in small areas at the margins of extreme flood levels which will occur briefly (less than one hour) and rarely (less than once in 50 years). A small amount of permanent bunding will securely isolate the Six Mile Well pit void from high-stage creek flow. The small incursions of the WRL onto the Jones Creek extreme flood zone are in areas of low stream velocity. Modelling has determined that catchment scale reduction in flow volume to be minor. Flow frequency and duration will be practically unaffected and total catchment discharge reduction will be approximately proportional to the catchment area reduction. Modelling shows that in most years that large scale catchment-wide flow occurs, the total annual yield greatly exceeds the capacity of the terminal Claypan such that the frequency of filling the Claypan will be barely diminished by the development. Road alignments have been adjusted to minimise impacts where possible and are not problematic from a hydrological perspective. Surface gradients along and across the proposed routes are generally low. Some relatively minor

		drawdown cone from dewatering and recovery of groundwater levels following completion of mining. Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline. Limit groundwater abstraction for Proposal water supply to pit dewatering, and existing NMK water supply (borefields and stormwater harvesting). Road design for haul route to include the following control measures: Breakaways - Grading exposes clay saprolite which may be to prone to erosion. Competent rock cladding of erosive material (clay saprolite) exposed in cuttings and in table drains on steeper sections, particularly within breakaways. Long slope-parallel sections - Erosion in the lateral table drain. Adequately close spacing of diversion drains. Oblique floodway crossings - Roadway capturing drainage. Additional sub-basecourse fill to raise the road profile on the down-slope size of the floodway Contour-parallel sections - Vegetation “shadowing”. Eliminate windrows in areas where overland flow needs to be maintained including swales, floodways (specific drainage features) and other areas where vegetation appears to be enhanced by overland flow perpendicular to the roadway. Undertake monitoring and adaptive management in accordance with the Hydrological Processes Environmental Management Plan (Appendix D). **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). In particular, backfilling of the Six Mile Well Pit will allow full recovery of groundwater levels	drainage measures, cut slope cladding and road surface profile modifications cladding are detailed. Groundwater modelling shows that drawdown of 5 metres will extend up to several hundred metres beyond the pit crest. In the baseline condition minor aquifers are typically submerged (confined) by 20 metres such that at maximum Proposal drawdown, they will remain fully saturated, and hence practically unimpacted, well within the 5-metre drawdown contour extent. Surface vegetation is not considered to be groundwater dependent due to depth to water table and will not be affected by either dewatering of post-closure potential rise in water table of 0.6m above baseline. Groundwater mounding is not considered to be a significant residual impact. The two stygofauna species found within the drawdown impact zone are considered to have distributions that extend beyond the impact zones through a network of hydraulic connections between the southern habitable portion of the Six Mile Well regolith aquifer and the alluvial, regolith and fractured rock groundwater systems associated with the Jones Creek drainage system. The drawdown is not likely to pose a long term conservation risk to these species. The ERD demonstrates that the development of the pits and the wider Proposal will not significantly impact on either the short or long term hydrological regimes of groundwater and surface waters, ensuring environmental values are maintained through the application of appropriate mitigation measures. NiW considers that the EPA’s objective for hydrological processes can be met.

Environmental Factor: Inland water environmental quality		**EPA Objective:** To maintain the quality of groundwater and surface water so that environmental values are protected	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Regionally the Proposal Development Envelope is located within the Lake Miranda catchment and at a local level, the upper reaches of the Jones Creek catchment. Jones Creek is an ephemeral water course which drains the largest catchment of the Barr Smith Range and includes a well-defined creek-bed which crosses the lower valley alluvial slopes and discharges to a Claypan near the valley axis. Generally the baseline water quality is low salinity, low turbidity, low levels of nickel and zinc with elevated copper, exceeding the ANZECC (2000) 80% protection trigger level for fresh water. Baseline stream sediment is typically 85% sand sized particles and up to 1.2% clay sized particles. Metal concentrations are generally well below the sediment quality guideline low trigger value for aquatic ecosystems ANZECC, (2000), with the exception of chromium and nickel which have been recorded at values between the ANZECC low and high trigger values. Groundwater is relatively scarce in the Proposal area, and lies 15 to 35m below the Development Envelope. The quality ranges from brackish to saline, neutral to slightly alkaline, dissolved cadmium, chromium, lead, selenium and zinc mostly below detection limits, elevated levels of boron and slightly elevated levels of nickel and chromium concentrations associated with the Six Mile Well ultramafic and dunite respectively.	Sedimentation of Jones Creek due to contaminated stormwater runoff from mining areas Sedimentation of drainage lines due to erosions of haul road Contamination of surface water by hydrocarbons and chemicals Oxidation of sulphidic ore causing acidic drainage Seepage of water from pit lakes to local groundwater post closure Stock and/or native fauna access to pit lakes and risks to animals as well as increased grazing/ trampling pressure on surrounding vegetation Disturbance resulting in a temporary loss or shift in aquatic habitat from the two creek crossings Sedimentation affecting water quality and aquatic biota Changes in surface hydrology that influence the composition of aquatic biota. Contamination posing a potential ecotoxicity risk to aquatic biota	**Avoid** Landforms designed to lie outside of flood impact zones. Haul route directly departs from the Jones Creek catchment. With the exception of the road crossings, the nearest Proposal feature is approximately 50m from Jones Creek. **Minimise** Disturbance to aquatic habitat and riparian vegetation within Jones Creek limited to construction of the two road crossings, which will maintain flow. Construction of stormwater diversion drains to reduce volume of stormwater over disturbed areas, reducing potential sedimentation and contamination of the creek. Construction of dirty water capture drains to capture stormwater from disturbed areas to silt traps, preventing sedimentation and contamination of the creek. Construction of bunds to prevent ingress of stormwater to the waste rock landform and divert flow back into catchment. Construction of clay bunds to prevent stormwater flow and contamination down creek lines blocked by the WRL. Coarse dumping of non-erodible/competent rock on the outer surface of the WRL. Peak flood flow exclusion bund constructed at south east pit perimeter of Six Mile Well pit. Divert dirty stormwater to silt traps and first flush check dams. Silt traps, check dams to be unlined to provide first flush storage capacity with overflow for ongoing runoff and designed to contain volume of 4mm runoff depth across sub-catchment.	The Proposal is located in the upper catchment of Jones Creek, where minor flows of several hours duration typically occur one to three times per year. Segregation of clean and dirty stormwater is the primary mitigation measure to protect local surface water quality. Stormwater diversion away from mining infrastructure and capture and treatment of contaminated stormwater will be implemented. Potential acid forming material will be encapsulated with high acid neutralizing capacity within the WRL. Seepage from the backfilled Six Mile Well pit and the Goliath pit lake to groundwater will be minor and of similar quality to existing groundwater. It is not anticipated that this landform will increase fauna or stock activity in the area, as access will be prevented by bunding and fencing. NiW considers that the residual impacts of the Proposal on surface water and groundwater quality are not significant and can be managed through the implementation of the proposed mitigation measures. Accordingly NiW considers the Proposal meets the EPA objectives for this factor.

		Rock cladding of erosion prone slopes graded for haul road construction (breakaways and creek crossings). Coarse rock armour of the exposed toe segment (500m) to a height which exceeds the 100 year peak flood level. Identification of PAF waste during drill and blast cycles and encapsulation within a designated cell in the WRL. Self-bunded fuel and chemical storage facilities. Undertake monitoring of groundwater quality in the vicinity of Six Mile Well pit. Undertake monitoring within Jones Creek (flow, water quality, sedimentation) and compare to baseline conditions (Appendix R). Post closure construction of abandonment bund and perimeter stock fencing around the final Goliath pit void and construction of bund across the top of pit access ramps and suitable egress point for fauna and stock (in the event abandonment bunds and fences are breached). Post closure diversion of diversion of surface water away from the pit to allow it to become hypersaline whilst also reducing stability (erosion) risks. **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	
Environmental Factor: Social Surroundings		**EPA Objective:** To protection social surroundings from significant harm	
Existing Environment	**Potential Impact**	**Management Measures**	**Predicted Outcome**
Aspect: Aboriginal Heritage			
The Proposal Development envelope lies within the Tjiwarl determination area (WAD228/2011 and WAD302/2015). The Tjiwarl consist of multiple family groups. Over time (pre and post determination), NiW (and predecessor companies) have consulted with members of these family groups regarding Aboriginal	Loss/disturbance to identified and unidentified Aboriginal heritage sites Constraints on traditional cultural activities Interruption to access to the heritage sites Alterations to hydrological processes associated with Jones Creek	**Avoid** Mine design has considered the Aboriginal heritage within the Development Envelope and has been through a substantial number of versions balancing economic and cultural concerns. By relocating the waste rock landform, NiW has been able to avoid impacts to the Barr-Smith Range (from a mythological perspective).	Despite efforts to avoid or minimise impacts on Aboriginal heritage sites, the Proposal may have a residual impact on twenty-three known places within the area for which s 18 consent was obtained in 2003. The most significant cultural heritage landscape features in the vicinity are the Barr-Smith Range and Jones Creek. The Aboriginal heritage and cultural values of the Barr-Smith Range will not be directly impacted. Jones Creek will be directly impacted at two creek crossing locations. No other part of Jones Creek will be directly impacted by this

heritage and cultural values in and around the Development Envelope. These consultations have included the engagement of Tjiwarl family groups as well as other Aboriginal people with cultural knowledge of the Development Envelope in heritage surveys. This broad consultation has resulted in the collection of a large amount of information about Aboriginal heritage and cultural values for the Development Envelope including about dreaming mythologies such as the joint mythology of the Tjinkunya (Dragon Fly) and Tjila (Carpet Snake) Dreaming (the Tjinkunya Tjila Dreaming). A range of different views have been expressed over time about the cultural heritage values of the Development Envelope including but not limited to ethnographic Aboriginal sites (as defined by the Aboriginal Heritage Act 1972 (AH Act)). Key areas of Indigenous cultural and social significance are: the Barr-Smith Range; and Jones Creek. These areas, and places associated with them are significant to members of the Tjiwarl People. The mythological narrative is associated with the range area of the Barr-Smith Range.		With respect to Jones Creek, direct impact of the proposed Development Envelope is limited to two crossings of the creek to access the pits, WRL and ROM pad. **Minimise** The Disturbance Footprint has been minimised by generating engineering solutions which have permitted the Proposal to remain feasible while reducing impacts on environmental and cultural values. All ground disturbance activities will be approved through the NiW EHIA process prior to commencing. Outside of the existing s 18 approval area, if there was insufficient information regarding potential or known heritage and cultural values, this process triggers further study or investigation. NiW intends to work together with the Tjiwarl to manage cultural heritage within the Proposal area. To further this goal a CHMP will be developed and will address appropriate contingency actions. **Salvage** Any cultural material salvaged due to a request of the traditional owners or as a condition of s 18 consents will be relocated on country or moved to a suitable cultural repository 'holding place' until such time as the material can be returned to country. Other salvaging activities could include photographic recordings, test pitting and 3 dimensional aerial drone capture of the surrounding landscape. **Rehabilitation** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E). Refinement of the final closure plans at the end of the mine life will be undertaken in consultation with the Tjiwarl.	Proposal. These crossings have been designed to minimise impact on flow through of the Creek and will not impact on creek flow through and the overall catchment drainage. The physical presence of the mining operations within a culturally significant landscape will be an indirect residual impact. This will be managed through ongoing engagement with the Tjiwarl. Some restrictions to access for traditional and cultural purposes including hunting and gathering will be required during the construction and operation of the mine. However, the development of the CHMP for the proposed operations will detail land access protocols for traditional owners and serve to strengthen and extend the cultural and heritage links with the area. Establishing these links will enable both parties to respect and consider approaches to mitigate impacts to the tangible and intangible heritage of the Development Envelope. NiW believes that with the proposed mitigation measures, the EPA objective for social surroundings as it relates to Aboriginal heritage can be met.
Aspect: Wanjarri Nature Reserve			
The Proposal lies to the west of the Wanjarri Nature Reserve, with	Impacts on amenity values of Wanjarri Nature Reserve, including:	**Avoid**	Amenity values can be highly subjective, with different levels of perception or tolerance of impacts. The residual impact of

the main haul road to Mt Keith abutting the western boundary of the Reserve.	Dust, noise, vibration and light emissions impacting on amenity of visitors to Wanjarri Nature Reserve. Visibility of the final waste rock landform from within the Reserve Interruption to public access to the Reserve.	Provision of a safe, alternative access route into Wanjarri Nature Reserve. **Minimise** Use of water based dust suppression on haul road, access ways and within mining areas. Use of chemical stabilisation in water based dust suppression on haul road nearest the NMK camp Speed controls on vehicle movements along the haul road to minimise dust generation. Blasting charge sizes limited to ensure ground borne vibration levels remain within prescribed daytime and night-time limits as measured from the camping area within Wanjarri Nature Reserve. Lighting limited to illumination of operational areas for safety requirements. **Rehabilitate** Proposal disturbance areas to be rehabilitated in accordance with the Proposal Mine Closure Plan (Appendix E).	noise, dust and light emissions on the amenity of the Wanjarri Nature Reserve are considered to be low: Noise emissions are expected to remain within prescribed limits for Wanjarri Nature Reserve. Blasting vibrations are not expected to impact on the reserve, with appropriate charge controls in place. Dust emissions are not expected to impact on visitor access to the Reserve and will be controlled along the western boundary of the Reserve where it abuts the haul road, through the use of water based dust suppression. Light emissions are expected to be limited to operational areas and rapidly dissipate with distance from the source. The most visible aspect of the Proposal will be the final waste rock landform. Visual impact assessment has found that it is likely this landform will be visible along some parts of the access into Wanjarri Nature Reserve inside the 10km viewshed, particularly where the vegetation is sparse. As vegetation density and distance increase, the landform is less visible. At key access points within the Reserve, being the Homestead and Shearing Shed, there is limited to no visibility of this landform. Continued, safe access to the Reserve will be maintained through an existing alternative access route. The residual impacts of the Proposal on the amenity values of Wanjarri Nature Reserve are minor and, with the exception of visibility of the final waste rock landform, can be mitigated with appropriate management measures. NiW considers that the EPA objectives for Social Surroundings as it relates to the values of Wanjarri Nature Reserve, can be met.

14 Conclusion

This document has provided information about the existing environment and potential impacts of implementation of the Proposal, in a local and regional context. This ERD explains NiW's management approach to potential impacts for each of the EPA's preliminary key environmental factors identified for the Proposal.

NiW has had due regard for the principles of ecological sustainable development of the EP Act and relevant EPA and other environmental guidelines.

NiW has extensive data sets and proven current management practises on which the EIAs were based, resulting in a high level of confidence in impact predictions. Inherent impacts have been assessed and application of the mitigation hierarchy applied to reduce potential impacts to a level NiW considers reasonable.

The EIA undertaken by NiW for this Proposal has concluded that for all factors outlined in the ESD, the EPA objectives can be met and the residual impacts to the environment resulting from the Proposal are not significant. NiW considers that the information and assessment presented in this ERD adequately identifies and addresses environmental impacts relevant to the Proposal, adequately addresses the environmental scoping document and is suitable to enable the EPA to undertake its EIA of the Proposal.

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