Note: KKN questions shown in greyed-out text have been closed out (i.e. required information has been attained) or removed (i.e. clearly no longer required, or covered in other KKNs)

					LANDFORM REHABILITATION THEME	
KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH)**
LAN1	Erosion	Baseline	LAN1. Determining baseline erosion and sediment transport characteristics in areas surrounding the RPA	LAN1A. What are the baseline rates of gully formation for areas surrounding the RPA?	Baseline information on gully characteristics and formation (e.g. extent/occurrence and distribution of gullies of differing size and complexity, rate of 'knick-point' retreat) in natural landforms is needed. This information can be obtained from appropriate imagery and will be used to assess whether the extent, rate and magnitude of gully formation predicted for the rehabilitated site will vary significantly from those observed in comparable non-mine disturbed landforms in adjacent areas.	SSB
				LAN1B. What are the baseline rates of sediment transport and deposition in creeks and billabongs?	The risk of bedload sediment transport from the rehabilitated site is generally considered to be low because of the ability to manage it through appropriate mitigation measures (e.g. sedimentation basins). However, information on natural bedload yields in Magela and Gulungul creeks is needed to distinguish mine-derived bedload from natural yields and monitor the effectiveness of mitigation measures. If the mitigation measures are not effective, this information would also be used to assess potential impacts to aquatic ecosystems.	BOTH
LAN2	Erosion	Baseline	LAN2. Understanding the landscape-scale processes and extreme events affecting landform stability	LAN2A. What major landscape-scale processes could impact the stability of the rehabilitated landform (e.g. fire, extreme events, climate)?	Identification of major landscape-scale processes or extreme events that could adversely affect the stability of the rehabilitated landform is needed to assess whether there are any potential risks associated with these processes that could result in mass failure and containment of tailings for at least 10,000 years. This information is likely to be available in existing reports and will be used to assess potential impacts on landform stability (see LAN2B).	SSB
				LAN2B. How will these landscape-scale processes impact the stability of the rehabilitated landform (e.g. mass failure, subsidence)?	Information to assess the degree to which major landscape-scale processes or extreme events could affect the stability of the rehabilitated landform is being addressed and will be further sought from the available literature.	BOTH
LAN3	Erosion	Predicting	LAN3. Predicting erosion of the rehabilitated landform	LAN3A. What is the optimal landform shape and surface (e.g. riplines, substrate characteristics) that will minimise erosion?	The shape (e.g. slope) and surface characteristics (e.g. particle size, roughness, riplines, drainage) of the rehabilitated landform will influence erosion rates. These characteristics and their effect on erosion rates can be assessed through an iterative modelling approach using CAESAR-Lisflood. Information on proposed landform characteristics should be used to optimise landform design. This could include using 'geomorphic reclamation' processes, which are the characteristics (e.g. slope curvature/length) of the pre-mining or adjacent landscape. These will be calculated and used to inform the design of the final landform.	ERA

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				LANDFORM REHABILITATION THEME		
KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH)
	ERA			LAN3B. Where, when and how much consolidation will occur on the landform?	The degree of subsidence within the rehabilitated landform (e.g. over Pits 1 and 3 associated with tailings consolidation) may influence erosional processes. Determining these rates will require some knowledge of predicted location and extent of consolidation over the pits.	ERA
				LAN3C. How can we optimise the landform evolution model to predict the erosion characteristics of the final landform (e.g. refining parameters, validation using bedload, suspended sediment and erosion measurements, quantification of uncertainty and modelling scenarios)?	Some input parameters for the landform evolution model may be influenced by local conditions and these need to be understood to maximise the accuracy of the model predictions. Examples of parameters include: • sediment settling velocity, • shear stress and roughness, • rate of weathering for waste rock, • effect of vegetation succession and fire on suspended sediment transport, and • impact of extreme rainfall events and scenarios over time on suspended sediment transport. Validation of bedload predictions could be undertaken by comparing measured parameters from the trial landform and the rehabilitated Pit 1 landform (e.g. bedload, suspended sediments) with the model outputs at both plot and catchment scale.	SSB
				LAN3D. What are the erosion characteristics of the final landform under a range of modelling scenarios (e.g. location, extent, timeframe, groundwater expression and effectiveness of mitigations)?	In order to assess the effectiveness of the final landform design (including any integral control structures), it will be necessary to identify and understand the erosion characteristics (extent and magnitude of gully formation; denudation and erosion rate; potential for groundwater expression) that may result under the different model scenarios.	SSB
				LAN3E. How much suspended sediment will be transported from the rehabilitated site (including land application areas) by surface water?	Suspended sediment has the potential to impact on aquatic ecosystems downstream of the rehabilitated site. Turbidity/suspended sediment should be monitored on the constructed Pit 1 final landform to determine what loads are likely to be released from the mine site and to assist with the calibration/validation of model predictions of suspended sediment transport at the catchment scale. The significance of suspended sediment that may be transported from land application areas will also need to be assessed. This assessment is commensurate with the level of soil disturbance associated with remediation of these areas.	BOTH

				WATER AND SEDIMENT REHABILITATION THEME		
KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
WS1	Biodiversity and ecosystem health	Source	WS1. Characterising contaminant sources on the RPA	WS1A. What contaminants (including nutrients) are present on the rehabilitated site (e.g. contaminated soils, sediments and groundwater; tailings and waste rock)?	A comparative assessment of contaminants of potential concern (COPCs) and their respective source(s) (e.g. waste rock, tailings/pore water, groundwater, soils) is needed, including consideration of any 'hotspots' that may be present on the rehabilitated site (e.g. groundwater under the plant area, GCT2 area, LAAs, billabong/stream sediments). This information contributes to whole-of-site contaminant transport modelling to predict post-closure water quality and will inform the rehabilitation and risk management of the site.	ERA
				WS1B. What factors are likely to be present that influence the mobilisation of contaminants from their source(s)?	For each contaminant source present on the rehabilitated site, physical, chemical and other factors that affect, or interact to affect, contaminant mobilisation need to be identified and assessed. This information contributes to whole-of-site contaminant transport modelling to predict post-closure water quality and will inform the rehabilitation and risk management of the site.	ERA
WS2	Biodiversity and ecosystem health	Pathway	WS2. Predicting transport of contaminants in groundwater	WS2A. What is the nature and extent of groundwater movement, now and over the long-term?	Knowledge of current and post-closure groundwater movement is required, both within the rehabilitated site and to the off-site environment. This is being achieved through numerical model predictions that consider the implications of changes to the groundwater movement due to the mine closure and recovery, i.e. the return to a stable state of levels, contaminant concentrations, flow paths and the influence of sea-level rise on groundwater flow, after rehabilitation. The most appropriate monitoring locations for calibration and verification of models needs consideration. This information contributes to whole-of-site contaminant transport modelling to predict post-closure water quality and will inform the rehabilitation and risk management of the site.	ERA
				WS2B. What factors are likely to be present that influence contaminant (including nutrients) transport in the groundwater pathway?	There is a need to determine whether conservative modelling or reactive modelling provides a worse-case for contaminant transport within the groundwater pathway. Reactive modelling examines physical and chemical factors that influence contaminant transport within the groundwater pathway (e.g. pH, redox conditions) and interactions amongst these (e.g. COPC mixtures). Identification of these factors (and their significance) informs contaminant transport modelling to predict the downstream concentrations of COPCs.	ERA
				WS2C. What are predicted contaminant (including nutrients) concentrations in groundwater over time?	The contaminant concentration in the groundwater system will vary with time due to the development of geochemical reactions at the source and movement of contaminants through the groundwater. Understanding of the variation of contaminant concentration will be used to determine the timing and amount of contaminant that may reach a receptor affecting the health of the ecosystem. Knowledge of the concentrations of COPCs in groundwater informs contaminant transport modelling used to predict the downstream concentrations of COPCs and inform rehabilitation and risk mitigation strategies.	ERA

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KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH)
WS3	Biodiversity and ecosystem health	Pathway	WS3. Predicting transport of contaminants in surface water	WS3A. What is the nature and extent of surface water movement, now and over the long-term?	Detailed information on current and future hydrological conditions for catchments both within the RPA and adjacent/downstream areas is required. The effect of sea-level rise on the surface waters flow also needs consideration. The timing and magnitude of surface water flows informs contaminant transport modelling used to predict the on-site and downstream concentrations of COPCs.	ERA
				WS3B. What concentrations of contaminants from the rehabilitated site will aquatic (surface and ground-water dependent) ecosystems be exposed to?	Determination of the concentrations of COPCs that aquatic ecosystems (including riparian vegetation) will be exposed to from the rehabilitated site needs to be based on the integration of modelling predictions for both groundwater (WS2) and surface water (WS3). Predicted COPC concentrations in surface and groundwaters can then be compared against water quality guideline values or other locally-derived biological effects information (for ground-water dependant species) in order to assess whether aquatic biodiversity and ecosystem health are exposed to risk following rehabilitation. (To address this KKN, information from WS3D is first required.)	ERA
				WS3C. What factors are likely to be present that influence contaminant (including nutrients) transport in the surface water pathway?	There is a need to determine whether conservative modelling or reactive modelling provides a worse-case for contaminant transport in the surface water pathway. Reactive modelling examines physical and chemical factors that will influence contaminant transport and toxicity (e.g. pH) and interactions amongst these (e.g. COPC mixtures). Identification of these factors (and their significance) informs contaminant transport modelling used to predict the downstream concentrations of COPCs.	ERA
				WS3D. Where and when does groundwater discharge to surface water?	Information on the locations and timing of groundwater discharge to surface water is required to assess the significance of this contaminant transport pathway. Improved understanding of groundwater/surface water interactions informs contaminant transport modelling used to predict the downstream concentrations of COPCs.	BOTH
				WS3E. What factors are likely to be present that influence contaminant transport (including nutrients) between groundwater and surface water?	Factors that could influence movement of contaminants, and limit or increase their concentration from groundwater to surface water, include geology, topography, aquifer geometry and hydraulic characteristics. Identification of these factors (and their significance) informs contaminant transport modelling to predict the downstream concentrations of COPCs.	ERA
				WS3F. What are the predicted concentrations of suspended sediment and contaminants (including nutrients) bound to suspended sediments in surface waters over time?	When suspended sediments are transported from the rehabilitated site, they could affect aquatic ecosystem health directly (e.g. habitats/biota effects) and/or indirectly (e.g. transport of bound contaminants). Knowledge of the concentrations of suspended sediments and associated contaminants informs contaminant transport modelling to predict the downstream concentrations of COPCs.	BOTH

				WATER AND SEDIMENT REHABILITATION THEME		
KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
				WS3G. To what extent will the interaction of contaminants between sediment and surface water affect their respective qualities?	Contaminants in surface water may accumulate in sediments to concentrations above those at which biological effects could be expected. Conversely, contaminants in sediments may resuspend into the water column and reduce water quality. An understanding of the factors affecting the flux of contaminants between surface waters and sediments is required to determine if closure criteria will protect both environmental compartments.	BOTH
				WS3H. Where and when will suspended sediments and associated contaminants accumulate downstream?	If contaminants from the rehabilitated site accumulate in downstream sediments, it is possible that they could affect aquatic ecosystem health directly and in the short term (e.g. to benthic biota) and/or in future through re-mobilisation of deposited contaminants. Knowledge of locations and likely timing for deposition of suspended sediments and associated contaminants informs the assessment of risk to aquatic ecosystems.	ERA
WS4	Biodiversity and ecosystem health	Receptor	WS4. Characterising baseline aquatic biodiversity and ecosystem health	WS4A. What are the nature and extent of baseline surface water, hyporheic and stygofauna communities, as well as other groundwater dependent ecosystems, and their associated environmental conditions?	Although there is currently substantial knowledge on baseline water quality and biodiversity in surface waters during early dry season (recessional) flow periods, information on water quality and biota for other periods of surface water flow and inundation (i.e. both wet and dry seasons, stream channels and billabongs) is limited. More complete information will allow a more comprehensive assessment of whether predicted (modelled) concentrations of COPCs transported from the rehabilitated site are likely to impact on downstream aquatic ecosystem health. Hyporheic and stygofauna communities in the Magela Creek sand beds are poorly understood and the significance of their contribution to ecological processes to the biodiversity of the ARR is unknown. The environmental conditions sustaining these (e.g. water quality, flow), and other groundwater dependent ecosystems (e.g. dry season water sources for riparian vegetation) are also unknown. If these communities are ecologically important, their potential sensitivity to increased solute loads needs to be assessed (WS7C). This information helps determine if specific closure criteria are needed to protect these communities.	SSB
WS5	Biodiversity and ecosystem health	Receptor	WS5. Determining the impact of contaminated sediments on aquatic biodiversity and ecosystem health	WS5A. Will contaminants in sediments result in biological impacts, including the effects of acid sulfate sediments?	Some COPCs transported from the rehabilitated site, e.g. uranium and sulfate, will bind to organic matter and benthic sediments in downstream ecosystems, in particular, the shallow lowland billabongs. The long-term risk of accumulation of these COPCs in sediment to biodiversity or ecological processes needs to be assessed for both the creek and billabongs. This information will inform management of the rehabilitated site and, in relation to sulfate in particular, any ongoing need to manage this COPC in surface and groundwater. Such a risk assessment would include analyses of the temporal trends in COPC concentrations in the sediments and, for sulfate, the predicted budget for billabongs (i.e. Coonjimba, Georgetown, Gulungul) to assess the risk of acid sulfate sediment formation and associated potential impacts on aquatic biodiversity and ecosystem health.	BOTH

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KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
				WS5B. What are the factors that influence the bioavailability and toxicity of contaminants in sediment?	Closure criteria for U in sediments were derived using sediments from Gulungul Billabong, as they are representative of the major depositional zones in and outside of the RPA (i.e. shallow backflow billabongs). However, if physico-chemical conditions (e.g. pH, TOC) of sediments differ from those in Gulungul Billabong, this may affect the toxicity of COPCs, and the closure criteria may not be appropriate. Knowledge of the influence of bioavailability and toxicity modifying factors in sediments helps derive closure criteria specific for different sediment conditions.	SSB
				WS5C. What would be the impact of contaminated sediments to surface aquatic ecosystems?	If predicted COPC concentrations in sediments are likely to reach a threshold where there is a risk that they could be mobilised into surface waters, the potential impacts to these aquatic ecosystems need to be assessed.	*Removed November 2019*
WS6	Biodiversity and ecosystem health	Receptor	WS6. Determining the impact of nutrients in surface water on aquatic biodiversity and ecosystem health	WS6A. What is the toxicity of ammonia to local aquatic species, considering varying local conditions (e.g. pH and temperature)?	The effects of ammonia on local species under local conditions need to be quantified. The toxicity of ammonia is highly influenced by pH and temperature, which can vary substantially between billabongs and streams, and seasonally. This research also needs to include assessment of toxicity to freshwater mussels, which have been reported as particularly sensitive to ammonia, an important component of the local aquatic ecosystem and a highly-valued food source for traditional owners. This information assists in deriving site-specific closure criteria for ammonia.	SSB
				WS6B. Can Annual Additional Load Limits (AALL) be used to inform ammonia closure criteria?	A review of the literature supporting AALLs is needed to understand their continuing relevance. It needs to be determined whether ammonia loads could be considered in the same context as the AALLs.	ERA
				WS6C. Will the total loads of nutrients (N and P) to surface waters cause eutrophication?	Contaminant transport modelling will predict loads of nutrients that downstream surface waters are likely to receive from the rehabilitated site. This information should be used to assess if there is a risk of eutrophication to downstream surface waters.	ERA
WS7	Biodiversity and ecosystem health	Receptor	WS7. Determining the impact of contaminants in surface and ground-water on aquatic biodiversity and ecosystem health	WS7A. Are current guideline values appropriate given the potential for variability in toxicity due to mixtures, modifying factors and different exposure scenarios?	Water quality limits that have been derived for individual toxicants do not incorporate potential interactive (e.g. additive, synergistic, antagonistic) effects of toxicant mixtures or other modifying effects occurring in the field (e.g. pH, temperature, DOC). This knowledge informs the development and application of closure criteria for COPCs.	SSB
				WS7B. What is the risk associated with emerging contaminants?	Contaminant research has been prioritised on a risk basis, but the continued gathering of contaminant knowledge before and during the mine's transition into a rehabilitated site may result in the identification of new or emerging contaminants of potential concern (e.g. contaminated sites studies and where the risk profile of a contaminant changes through increased knowledge of effects or exposure). Where such contaminants are identified, they need to be assessed using a tiered, risk-based approach.	BOTH

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KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH)
				WS7C. Are current guideline values appropriate to protect the key groups of aquatic organisms that have not been represented in laboratory and field toxicity assessments (e.g. flow-dependent insects, hyporheic biota and stygofauna)?	Current guideline values are derived from a limited suite of laboratory tests and, where possible, validated using field-effects data. Some (sandy) stream-dwelling species, which have been reported as sensitive to contaminants, are not represented in these data sets and their sensitivity to COPCs are unknown. This knowledge will indicate if closure criteria are protective of these taxa and identify any phase of the hydrograph of receiving stream environments that represents greater risks to stream biota than other phases.	SSB
				WS7D. How do acidification events impact upon, or influence the toxicity of contaminants to, aquatic biota?	Acidification events, and associated increases in dissolved metal concentrations, have been observed in on-site waterbodies (e.g. Coonjimba Billabong, RP1) as a result of acid sulfate soil formation associated with elevated sulfate concentrations from the mine. These events typically occur during re-wetting events in the early wet season and in most cases are short-lived (days, weeks). In order to fully inform management actions for sulfate in surface and groundwaters (see WS5A), biological-effects studies of the impacts to such receiving waters should be undertaken to examine short (during events) and longer-term (seasonal, interannual) changes to biodiversity and ecological processes.	*Removed November 2019*
				WS7E. How will Mg:Ca ratios influence Mg toxicity?	An understanding of the Mg:Ca ratio of seepage water from various sources and how this affects toxicity is required. The gathering of field (or semi-field) effects data for mine released waters (including groundwater sources) mixed with receiving waters would provide supporting evidence.	SSB
				WS7F. Can a contaminant plume in creek channels form a barrier that inhibits organism migration and connectivity (e.g. fish migration, invertebrate drift, gene flow)?	Previous studies in Magela Creek have demonstrated avoidance by fish of mine wastewater discharges, indicating potential reduced recruitment to upstream sites. Information on seasonal movement and dispersal of organisms needs to be considered and combined with groundwater contaminant modelling data, in order to assess potential for impaired movement and connectivity in streams.	SSB
				WS7G. What concentrations of contaminants will be detrimental to the health of (non-riparian) aquatic vegetation?	The guideline values for COPCs were derived using a limited species range that included one aquatic macrophyte (*Lemna*) with a relatively short exposure duration (4 days). Apart from their inherent biodiversity and conservation values, the diverse aquatic plant communities in billabongs and along littoral portions of the creeks constitute critical habitat for other biota, and for this reason are deserving of more detailed investigation than just the limited laboratory information available for the single species. Laboratory and field studies under a range of realistic exposure scenarios or across existing contaminant gradients in onsite waterbodies should be undertaken to assess the potential sub-lethal impacts of COPCs on aquatic vegetation in these aquatic ecosystems and thereby determine if healthy aquatic habitats can be maintained following rehabilitation.	BOTH

				WATER AND SEDIMENT REHABILITATION THEME		
KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
				WS7H. What concentrations of contaminants will be detrimental to the health of riparian vegetation?	Riparian vegetation, particularly that growing along the banks of the major drainage lines (Magela and Gulungul creeks) may be seasonally exposed to elevated concentrations of contaminants in shallow groundwater after minesite rehabilitation. An assessment of the potential sub-lethal impacts of COPCs on germination and early growth of representative species (e.g. through pot trials) will assist in determining if healthy riparian habitats can be maintained following rehabilitation.	SSB
WS8	Biodiversity and ecosystem health	Receptor	WS8. Determining the impact of suspended sediment on aquatic biodiversity and ecosystem health	WS8A. What are the physical effects of suspended sediment on aquatic biodiversity, including impacts from sedimentation and variation in sediment characteristics (e.g. particle size and shape)?	Suspended sediments can have various physical effects on aquatic ecosystems, such as habitat alteration (e.g. deposition), light attenuation and subsequent influence on primary productivity and physiological effects on organisms (e.g. inhibition of reproduction/growth, fish gill function). The magnitude of the effects of suspended sediments can vary according to their characteristics. For example, larger particle sizes are more likely to result in impacts associated with deposition (e.g. smothering of habitat), whereas smaller particle sizes are more likely to result in impacts upon filter feeding organisms. An assessment of potential impacts of suspended sediment on aquatic biodiversity should be based on predicted characteristics of sediments that may be transported from the rehabilitated site.	SSB
				WS8B. To what extent does salinity affect suspended particulates, and what are the ecological impacts of this?	Salinity can affect behaviour of suspended particles by processes such as flocculation and may affect the rate at which the particles settle from the water column. The potential for high-salinity waters associated with the rehabilitated site (e.g. evapo-concentration in billabongs during the dry season) to affect behaviour of suspended particulates (e.g. increased deposition rates) and subsequent ecological impacts (e.g. infilling of billabongs) needs to be assessed.	SSB

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					HEALTH IMPACTS OF RADIATION AND CONTAMINANTS REHABILITATION THEME	
KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
RAD1	Human and ecosystem health	Source	RAD1. Radionuclides in the rehabilitated site	RAD1A. What are the activity concentrations of uranium and actinium series radionuclides in the rehabilitated site, including waste rock, tailings and land application areas?	Waste rock, buried tailings and contaminated soils on land application areas represent potential sources of radionuclides to the environment from the rehabilitated site. The radionuclides of concern are those of the uranium and actinium decay series because they occur at elevated concentrations in the source materials. Radionuclides of the thorium decay series are not of concern, as they do not occur at elevated levels in the source materials. Knowledge of the activity concentrations of uranium and actinium decay series radionuclides in waste rock, tailings and land application area soils is needed to model activity concentrations in the environment post-rehabilitation, which in turn are needed to estimate radiation doses to the public and wildlife. The knowledge could be acquired through radionuclide measurements on existing waste rock, tailings and land application area soils.	ERA
RAD2	Human and ecosystem health	Pathway	RAD2. Radionuclides in aquatic ecosystems	RAD2A. What are the above-background activity concentrations of uranium and actinium series radionuclides in surface water and sediment?	Increased radionuclide activity concentrations in surface water and sediment due to contaminated water arising from the rehabilitated site could result in radiation doses above natural background to the public and wildlife. Knowledge of the increases in activity concentrations of uranium and actinium decay series radionuclides in surface water and sediment is needed to estimate these doses. The knowledge could be acquired through modelling of: • radionuclide releases to surface water via runoff and groundwater pathways from the rehabilitated site • the mixing of released radionuclides in surface water • radionuclide partitioning between sediment and water. Furthermore, the modelling of radionuclide releases could be based on an element with high solubility to provide conservative estimates of activity concentrations.	ERA
RAD3	Human and ecosystem health	Pathway	RAD3. Radon progeny in air	RAD3A. What is the above-background concentration of radon and radon progeny in air from the rehabilitated site?	Radon (a radioactive gas) will be emitted to the atmosphere from the rehabilitated site due to the decay of radium-226 in surface waste rock. The inhalation of radon progeny radionuclides produced through the decay of emitted radon could result in radiation doses above natural background to the public. Knowledge of radon and/or radon progeny concentrations in air is needed to estimate these doses. This knowledge could be acquired by modelling the atmospheric dispersion of radon from the rehabilitated site, using site-specific data (as necessary) for parameters such as: • radium-226 activity concentrations in surface waste rock (RAD1A) • radon exhalation rates for waste rock • dry and wet season meteorological conditions.	SSB

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KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**		**Responsibility (SSB/ERA/BOTH**
				RAD3B. If an assessment using conservative values shows a potential issue with meeting closure criteria (3A and 7A): What is the equilibrium factor between radon progeny and radon in air?	If the modelling under RAD3A gives radon concentrations in air, then knowledge of the equilibrium factor between radon progeny and radon will be needed to obtain radon progeny concentrations for dose modelling. If needed, site-specific knowledge on equilibrium factors could potentially be acquired through simultaneous measurements of radon and radon progeny concentrations in ambient air off-site of the operating mine.		*Removed November 2019*
				RAD3C. If an assessment using conservative values shows a potential issue with meeting closure criteria (3A and 7A): What is the unattached fraction of radon progeny in air?	The dose coefficient for radon progeny depends on the proportion of radon progeny attached and unattached to aerosols. If needed, site-specific knowledge on the unattached fraction could be acquired through simultaneous measurements of radon progeny attached and unattached to aerosols in ambient air at locations off-site of the operating mine.		*Removed November 2019*
RAD4	Human and ecosystem health	Pathway	RAD4. Radionuclides in dust	RAD4A. If an assessment using conservative values shows a potential issue with meeting closure criteria (4B and 7A): What is the resuspension factor (or emission rate) of dust emitted from the final landform?	If the modelling under RAD4B uses a resuspension factor approach to estimate the release of radionuclides in dust from the rehabilitated site to the atmosphere, then site-specific knowledge of dust resuspension factors or emission rates may be needed. If needed, this knowledge could be acquired through measurements of radionuclide activity loadings in dust and activity concentrations in ambient air.		*Removed November 2019*
				RAD4B. What is the above-background activity concentration in air of long-lived alpha-emitting radionuclides in dust emitted from the final landform?	The inhalation of radionuclides in dust emitted to the atmosphere from the rehabilitated site could result in radiation doses above natural background to the public. Knowledge of airborne activity concentrations of radionuclides in dust is needed to estimate these doses. This knowledge could be acquired by modelling the atmospheric dispersion of radionuclides in dust from the rehabilitated site, using site-specific data (as necessary) for parameters such as: • activity concentrations of uranium and actinium decay series radionuclides in surface waste rock (RAD1A) • resuspension factors (or emission rates) of radionuclides in dust from waste rock • dry and wet season meteorological conditions.		*Closed out November 2019*
				RAD4C. If an assessment using conservative values shows a potential issue with meeting closure criteria (4B and 7A): What is the activity median aerodynamic diameter of long-lived alpha-emitting radionuclides in dust emitted from the final landform?	The dose coefficient for radionuclides in dust depends on the activity median aerodynamic diameter (i.e. size) of the aerosol. If needed, site-specific knowledge on activity median aerodynamic diameter could be acquired through radionuclide measurement of size fractionated dust samples collected using cascade impactors.		*Removed November 2019*

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KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
RAD5	Human and ecosystem health	Pathway	RAD5. Radionuclides in bushfoods	RAD5A. What are the concentration ratios of actinium-227 and protactinium-231 in bush foods?	The ingestion of uranium and actinium decay series radionuclides bioaccumulated in bush foods could result in radiation doses above natural background to the public. Radiation dose assessments for the human food chain use concentration ratios to predict radionuclide activity concentrations in food items from those in the surrounding soil or water. A sizeable body of knowledge exists on concentration ratios for uranium decay series radionuclides. However, there is effectively no knowledge (site-specific or otherwise) on concentration ratios for actinium decay series radionuclides. The actinium decay series radionuclides of potential concern include actinium-227 and protactinium-231, which have relatively high ingestion dose coefficients. Knowledge on concentration ratios for these radionuclides could potentially be acquired through sampling and measurement on bush foods and associated soils and waters after development of radiochemistry separation and measurement techniques for actinium-227 and protactinium-231.	SSB
RAD6	Human and ecosystem health	Receptor	RAD6. Radiation dose to wildlife	RAD6A. What are the representative organism groups that should be used in wildlife dose assessments for the rehabilitated site?	Wildlife dose assessments are generally based on a small number of organism groups representative of the broad variety of species present in the environment. This is because it is not usually practical to sample and perform radionuclide analyses on all species present. Knowledge of representative organism groups could potentially be acquired from reviewing ecological information about the species present in the local environment and generalising them up to a small number of representative organism groups. Alternatively, broad wildlife groups defined by international bodies (e.g. International Atomic Energy Agency) or within wildlife dose assessment tools (e.g. ERICA) could potentially be used. When selecting representative organism groups, consideration should be given to any rare, threatened or culturally significant species that may be present in the local environment.	*Closed out November 2019*

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colspan="7"	**HEALTH IMPACTS OF RADIATION AND CONTAMINANTS REHABILITATION THEME**
KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
				RAD6B. What are the whole-organism concentration ratios of uranium and actinium series radionuclides in wildlife represented by the representative organism groups?	The bioaccumulation of uranium and actinium decay series radionuclides in wildlife could result in radiation doses above natural background to those wildlife. Standard dose assessment tools for wildlife use whole organism concentration ratios to predict radionuclide activity concentrations in wildlife from those in the surrounding soil or water. Whole organism concentration ratios of uranium decay series radionuclides have been derived for some (but not all) types of wildlife using site-specific data. There is effectively no data (site-specific or otherwise) for deriving whole organism concentration ratios for actinium decay series radionuclides, specifically actinium-227 and protactinium-231. Knowledge of whole organism concentration ratios for uranium and actinium decay series radionuclides could potentially be acquired by one or more of the following methods: • sampling and radionuclide measurements on organisms and associated soil or water to derive additional site-specific values • review and analysis of international databases (e.g. Wildlife Transfer Database) and publications to fill gaps in site-specific values • use of surrogate organism and analogue element approaches to fill gaps in site-specific values.	SSB
				RAD6C. What are the tissue to whole organism conversion factors for uranium and actinium series radionuclides for wildlife represented by the representative organism groups?	Standard dose assessment tools for wildlife use whole organism concentration ratios to predict radionuclide activity concentrations in wildlife from those in the surrounding soil or water. Most site-specific data on radionuclide activity concentrations in wildlife is tissue-specific, as it was originally collected to support human food chain dose assessments. The data need to be converted to whole organism values to be useful in wildlife dose assessments. Knowledge on tissue to whole organism conversion factors could be acquired by one or more of the following methods: • review and analysis of existing site-specific data to reconstruct whole organisms from individual tissues using a mass balance approach • sampling and radionuclide measurements on the individual tissues comprising whole organisms • review and analysis of international databases and publications • use of surrogate organism and analogue element approaches to fill knowledge gaps.	SSB

HEALTH IMPACTS OF RADIATION AND CONTAMINANTS REHABILITATION THEME

KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
				RAD6D. What are the dose-effect relationships for wildlife represented by the representative organism groups?	The potential radiation risk to wildlife can be evaluated by comparing whole organism dose rates to environmental reference levels, which generally represent the dose rates at which radiation effects in organisms may begin to occur. Environmental reference levels derived by international bodies are currently used within the rehabilitation standard for radiation protection of the environment. If needed, dose-effect relationships for specific organism groups could be derived by one or more of the following methods: • laboratory studies within which aquatic and terrestrial organisms are chronically exposed to known activities of radionuclides and the effects on key biological endpoints (i.e. mortality, morbidity, reproduction and genetic mutations) observed • review of international databases (e.g. FREDERICA) and publications.	SSB
				RAD6E. What is the sensitivity of model parameters on the assessed radiation doses to wildlife?	Radiation dose modelling for wildlife uses a large number of parameters. The potential variability in parameter values used in the modelling can cause variability in the estimate of the dose to wildlife. Sensitivity analysis is a standard method that can be used to identify key parameters causing variability in modelling results. Understanding the variability in dose modelling results due to each input parameter is important so that research to acquire additional site-specific knowledge (if needed) can be appropriately prioritised and targeted.	ERA
RAD7	Human and ecosystem health	Receptor	RAD7. Radiation dose to the public	RAD7A. What is the above-background radiation dose to the public from all exposure pathways traceable to the rehabilitated site?	The pathways through which the public can be exposed to radiation due to the rehabilitated site are: • inhalation of radon progeny and radionuclides in dust • ingestion of bush foods and drinking water • external gamma The statutory limit on radiation dose to the public applies to the dose above natural background from all sources and exposure pathways summed. The assessment of radiation dose to the public due to the rehabilitated site requires an analysis of each exposure pathway for a clearly defined scenario of future land use. Parameterisation of exposure pathways can be made using existing knowledge and that acquired under RAD1A, RAD2A, RAD3A, RAD3B, RAD3C, RAD4A, RAD4B, RAD4C and RAD5A. Knowledge on future land use to develop a quantitative scenario against which radiation doses can be assessed can potentially be acquired by : • consultation with traditional owners • review of the literature or other records for information on historic use of the area	ERA

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KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
				RAD7B. What is the sensitivity of model parameters on the assessed doses to the public?	Radiation dose modelling uses a large number of parameters to estimate doses to the public. The potential variability in parameter values used in the modelling can cause variability in the estimate of the dose. Sensitivity analysis is a standard method that can be used to identify key parameters causing variability in modelling results. Understanding the potential variability in the estimated dose due to each input parameter is important so that research to acquire additional site-specific knowledge (if needed) can be appropriately prioritised and targeted.	ERA
RAD8	Ecosystem health	Receptor	RAD8. Impacts of contaminants on wildlife	RAD8A. Will contaminant concentrations in surface water (including creeks, billabongs and seeps) pose a risk of chronic or acute impacts to terrestrial wildlife?	Wildlife may drink water from waterbodies affected by the mine but their intake profile from these sources is not aligned with the models of intake on which livestock drinking water guidelines are based (e.g. infrequent, occasional use versus longer-term frequent use). Livestock drinking guidelines are probably not appropriate for small wildlife or taxa such as reptiles. An assessment of the risks associated with both chronic and acute impacts to all large and small terrestrial wildlife needs to take into account how much of an animal's consumption is likely to come from poor quality sources associated with the rehabilitated site. This information will determine if specific water quality closure criteria are required to protect large and small terrestrial wildlife.	SSB
RAD9	Human health	Receptor	RAD9. Impacts of contaminants on human health	RAD9A. What are the contaminants of potential concern to human health from the rehabilitated site?	Identification of the COPCs that may be elevated in soil (e.g. landform and LAAs) or water (e.g. creeks and billabongs) is a key first step in assessing potential risks to human health. A screening approach to identify those COPCs with higher toxicity (from relevant drinking water guidelines) and which may also be present in the environment due to the rehabilitated site should be undertaken. This will inform whether closure criteria for human health are required.	ERA
				RAD9B. What are the concentration factors for contaminants in bush foods?	Human food-chain assessments of COPC exposure use concentration factors to quantify transfer from the environment (e.g. soil and water) to food items. This is particularly the case for prospective assessments, where exposure estimates are made from predicted soil or water COPC concentrations using concentration factors.	SSB
				RAD9C. What are the concentrations of contaminants in drinking water sources?	Dietary exposure to COPCs in drinking water will be proportional to the COPC concentrations in the water and the amount consumed.	ERA
				RAD9D. What is the dietary exposure of, and toxicity risk to, a member of the public associated with all contaminant sources, and is this within relevant Australian and/or international guidelines?	The total dietary intake of each COPC needs to be assessed and compared to relevant guideline values to determine the acceptability of the exposure in a human health context.	ERA

ECOSYSTEM RESTORATION REHABILITATION THEME

KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
ESR1	Ecosystem similarity	Ecosystem similarity	ESR1. Determining the requirements and characteristics of terrestrial vegetation in natural ecosystems adjacent to the mine site, including Kakadu National Park.	ESR1A. What are the compositional and structural characteristics of the terrestrial vegetation (including seasonally-inundated savanna) in natural ecosystems adjacent to the mine site, how do they vary spatially and temporally, and what are the factors that contribute to this variation?	Baseline information on terrestrial vegetation composition and structure at scales that adequately capture and explain heterogeneity in natural ecosystems is required. This information, historical or new, will be used in the development of closure criteria and to assess whether vegetation growing on the rehabilitated site is similar to reference sites observed in non-mine disturbed ecosystems in adjacent areas. Examples of compositional and structural characteristics of vegetation include species abundance, and density, number of species, size class distribution of trees and shrubs, vegetation strata (e.g. canopy or ground cover) and hollow abundance. Such information would ideally be based on large-scale survey methods (e.g. remote sensing) that will better capture the spatial and temporal variation than the historical smaller scale ground-based surveys. Accompanying environmental measurements are also required in order to identify factors accounting for the variations in vegetation. Identifying factors responsible for observed ecological patterns may assist in revegetation planning and establishment.	SSB
				ESR1B. Which indicators of similarity should be used to assess revegetation success?	The proposed vegetation similarity indicators have been drawn from the National Restoration Standards (Standards Reference Group SERA 2016) and include species composition, number of species, vegetation strata, tree/shrub class size distribution and vegetation distribution ('naturalness'). Closure criteria will be developed for these indicators and applied for each of these to assess the degree of similarity between vegetation growing on the rehabilitated site and that observed in non-mine disturbed ecosystems in adjacent areas. Indicators will be developed for both understorey and overstorey vegetation.	*Closed out November 2019*
				ESR1C. What values should be prescribed to each indicator of similarity to demonstrate revegetation success?	Once appropriate similarity indicators have been identified, specific value(s) for each need to be established that account for the expected range in natural spatial and temporal variability (i.e. avoidance of single numbers). This information will be used in the development of closure criteria and to assess whether vegetation growing on the rehabilitated site is progressing acceptably towards that observed in non-mine disturbed ecosystems in adjacent areas, the extent of such progress, and whether it has achieved an agreed level of similarity. The indicator values may vary according to the spatial scale at which they are derived and this dependence needs to be understood for future applications.	BOTH

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		ECOSYSTEM RESTORATION REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
ESR2	Ecosystem similarity	Ecosystem similarity	ESR2. Determining the requirements and characteristics of a terrestrial faunal community similar to natural ecosystems adjacent to the mine site, including Kakadu National Park	ESR2A. What faunal community structure (composition, relative abundance, functional groups) is present in natural ecosystems adjacent to the mine site, and what factors influence variation in these community parameters?	Much baseline information on terrestrial fauna community structure in natural ecosystems adjacent to the mine site is already available, but additional information may be required. This reference information will be used to characterise fauna communities in natural ecosystems adjacent to the mine site, the extent of variation in the fauna and the factors that influence such variation. This context will be used in the development of faunal community closure criteria and to measure and interpret progress of fauna communities in the rehabilitated site towards those in adjacent suitable reference locations. For vertebrates, such information would ideally be based on contemporary fauna survey methods (e.g. camera trapping) that will better capture the spatial and temporal variation than the historical survey techniques.	BOTH
				ESR2B. What habitat, including enhancements, should be provided on the rehabilitated site to ensure or expedite the colonisation of fauna, including threatened species?	The establishment of vegetation does not guarantee that suitable habitats for terrestrial fauna colonisation are available, particularly early in the ecosystem restoration process. Information is needed on the time that it may take before the rehabilitated site can be expected to naturally develop key fauna habitat features (e.g. tree hollows); if this is likely to be many years, options for habitat enhancements will need to be examined (e.g. nesting boxes, rock piles).	BOTH
				ESR2C. What is the risk of introduced animals (e.g. cats and dogs) to faunal colonisation and long-term sustainability?	The risk that introduced animals could impede the re-establishment of fauna and the long-term sustainability of faunal communities needs to be assessed. This is likely to be particularly important early in the ecosystem restoration process, when the rehabilitated landscape could provide optimal habitat for introduced animals (e.g. ideal conditions for predators) and before suitable habitats for native fauna are established (e.g. fallen logs, tree hollows for refuge). This information will inform the need for mitigation measures, such as active management of introduced animals and/or establishment of habitat enhancements that favour native fauna.	BOTH
ESR3	Ecosystem similarity	Ecosystem similarity	ESR3. Understanding how to establish native terrestrial vegetation, including understory species.	ESR3A. How do we successfully establish terrestrial vegetation, including understory (e.g. seed supply, seed treatment and timing of planting)?	The ability to establish the full range (or an appropriate complement) of native vegetation species from the reference ecosystem needs to be demonstrated. While this has been shown in initial trials for over 35 framework species, there is far less available evidence for the successful establishment of a diverse suite of understorey species. This information will be sought from the literature, and from ongoing research including trials on the Ranger Trial Landform and, in future, on the Pit 1 rehabilitated site. The information will provide necessary assurance that it is possible to establish vegetation communities on the rehabilitated site that will be similar to adjacent non-mine disturbed ecosystems.	ERA

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KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
ESR4	Ecosystem similarity	Ecosystem similarity	ESR4. Determine the incidence and abundance of introduced species in natural ecosystems adjacent to the mine site, including Kakadu National Park, and their potential to impact on the successful rehabilitation of Ranger mine	ESR4A. What is the incidence and abundance of introduced animals and weeds in areas adjacent to the mine site, and what are the factors that will inform effective management of introduced species on the rehabilitated mine site?	Information on the composition and abundance of introduced species in areas adjacent to the rehabilitated site is required, both to assess the risk that these ecological stressors may pose to successful ecosystem restoration and to demonstrate that their presence on the site is not higher than in adjacent to areas. This information will be required throughout the restoration process to inform trigger points for implementing mitigation strategies (e.g. early detection of pests or weeds may allow for ready cost-effective eradications). Further research may be required to inform management options that (i) result in control of pests and weeds but (ii) do not prevent the successful restoration of native species and communities.	SSB
ESR5	Long term viability	Ecosystem Sustainability	ESR5. Develop a restoration trajectory for Ranger mine	ESR5A. What are the key sustainability indicators that should be used to measure restoration success?	The proposed indicators of long-term viability and ecosystem function (sustainability) of the restored ecosystem have been drawn from the National Restoration Standards (e.g. Standards Reference Group SERA 2016). These indicators include recruitment of revegetation, nutrient cycling, faunal usage, habitat availability, resilience to fire, extreme weather events, pests and diseases. Other attributes to be considered are external exchanges (e.g. habitat connectivity, physical conditions (e.g. nutrient availability), and absence of threats (e.g. weeds). This information will be used in the development of closure criteria and to assess whether ecosystems established on the rehabilitated site will be similar to those observed in natural non-mine disturbed ecosystems in adjacent areas.	BOTH
				ESR5B. What are possible/agreed restoration trajectories (flora and fauna) across the Ranger mine site; and which would ensure they will move to a sustainable ecosystem similar to those adjacent to the mine site, including Kakadu National Park?	Restoration trajectories will be required to assess the achievement of closure criteria that are expected to be reached after a period of time (e.g. decades) from the initial establishment. The trajectory approach outlined in the National Ecological Restoration Standards is based on modelling of a desired and/or expected trajectory pathway, distinguishing the desired pathway from possible undesired states, and selecting points within the desired trajectory that represent milestones leading to agreed closure. This should be based on previous regional revegetation studies, either at Ranger or elsewhere, and response of the savanna ecosystems to disturbance. The model should also consider scenarios (e.g. fire and weeds) that capture key aspects of revegetation establishment and natural disturbances. This information should also be used to identify and plan for management of risks and should form the basis for design and assessment of monitoring programs and results.	BOTH

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					ECOSYSTEM RESTORATION REHABILITATION THEME	
KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
ESR6	Long term viability	Ecosystem Sustainability	ESR6. Understanding the impact of contaminants on vegetation establishment and sustainability	ESR6A. What concentrations of contaminants from the rehabilitated site may be available for uptake by terrestrial plants?	Exposure of vegetation (both revegetation and existing native vegetation) to contaminants could occur from a number of sources on the rehabilitated site, such as waste rock, contaminated soils and groundwater. Integrated surface and groundwater modelling should identify areas of the rehabilitated site that may act as potential hotspots for increased concentrations of contaminants (see KKN WS1A), such as magnesium sulfate. The concentrations of contaminants available for uptake by terrestrial plants needs to be understood in order to assess whether there may be a risk to vegetation establishment and long term sustainability. For waste rock, which represents an unnatural substrate and plant medium, the assessment is conducted separately through KKN ESR7D.	BOTH
				ESR6B. Based on the structure and health of vegetation on the Land Application Areas, what species appear tolerant to the cumulative impacts of contaminants and other stressors over time?	Contaminants and/or other stressors associated with the operation of Land Application Areas have altered and impaired the structure and health of vegetation. While the presence of multiple stressors confounds the ability to isolate specific causes of impaired plant health, the identification of plants tolerant to multiple stressors (including contaminants) may assist in revegetation planning and establishment (e.g. selection of species best suited to locations of contaminant build-up and/or water-logging) and in assessing plant health, over the longer-term).	ERA
ESR7	Long term viability	Ecosystem sustainability	ESR7. Understanding the effect of waste rock properties on ecosystem establishment and sustainability	ESR7A. What is the potential for plant available nutrients (e.g. nitrogen and phosphorus) to be a limiting factor for sustainable nutrient cycling in waste rock?	There are likely to be substantial differences between waste rock and natural soils in nutrient concentrations (e.g. P, N, Mg, exchangeable K and S) and rhizobia/mycorrhizal fungi available to plants. Combined with a potential lag in the timing at which effective nutrient cycling processes develop in the waste rock, nutrient deficiency may impair the establishment and sustainability of healthy vegetation communities. Targeted monitoring of processes, including soil available nutrient levels and plant nutrient status in established vegetation, compared to levels in soils and plants in reference sites, can provide evidence (i.e. empirical data) of progression to a self-sustaining nutrient cycle. This information will assist in determining whether an active nutrient maintenance regime may be required for a period of time following rehabilitation.	ERA

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KKN No.	**ER Link**	**Category**	**Title**	**Questions**	**Description**	**Responsibility (SSB/ERA/BOTH**
				ESR7B. Will sufficient plant available water be available in the final landform to support a mature vegetation community?	Plant available water in waste rock substrate may be limited. Studies on the trial landform have demonstrated water holding capacity of the landform is comparable to the natural reference system. Despite uncertainties in measurements and modelling, the trial landform studies indicate that the waste rock of 4 m thickness may support mature vegetation similar to adjacent areas over short dry seasons but possibly not during longer dry seasons. Further information is needed to determine the availability of water in the waste rock substrate, such as: • influence of waste rock depth on water holding capacity • water availability at greater depths (e.g. 4-8 m) and ability of plants to access this (e.g. maximum rooting depths) • influence of waste rock particle size and pore spaces • contribution of understorey to evapotranspiration rates • uncertainty associated with water balance models and sensitivity of input parameters. These factors will need to take into account location (e.g. elevation and aspect) on the final landform.	ERA
				ESR7C. Will ecological processes required for vegetation sustainability (e.g. soil formation) occur on the rehabilitated landform and if not, what are the mitigation responses?	There is uncertainty about whether key ecological processes required to support sustainable vegetation communities will occur on the rehabilitated landform. It has also been assumed that rapid weathering of waste rock will occur to form rudimentary soil materials but there is little information to demonstrate that this will be applicable across the rehabilitated site (i.e. all types of waste rock materials). This information can be used to determine whether specific mitigations may be needed (e.g. addition of fines, mulch).	ERA
				ESR7D. Are there any other properties of the rehabilitated site that could be attributed to any observed impairment of ecosystem establishment and sustainability, including vegetation and key functional groups of soil fauna?	Apart from plant available water and nutrients, other factors need to be identified in the event that ecosystem establishment and sustainability are impaired. These factors may include, for example, sub-optimal light conditions for tubestock or water-logging of the landform at initial planting.	ERA

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KKN No.	ER Link	Category	Title	Questions	Description	Responsibility (SSB/ERA/BOTH
ESR8	Long term viability	Ecosystem Sustainability	ESR8. Understanding fire resilience and management in ecosystem restoration	ESR8A. What is the most appropriate fire management regime to ensure a fire resilient ecosystem on the rehabilitated site?	Fire can present a significant risk to long term sustainability of restored ecosystems. The current strategy is to exclude fire from revegetation areas for the first 5-7 years following initial planting, followed by the gradual introduction of fire to rehabilitated areas. With the large spatial extent of fires in the region, management of fires is a cross-jurisdictional issue and needs to be managed for ecosystem restoration success at multiple scales. More specific information is needed to determine the most appropriate fire management regime over time, from initial introduction to a regime that is similar to surrounding areas, including consideration of sensitive plant and animal species. Recent research in Kakadu National Park that modelled the effects of fire regimes on overstorey population dynamics would be particularly relevant to this knowledge need.	ERA

			CROSS-THEME REHABILITATION THEME			
KKN No.	ER Link	Category	Title	Questions	Description	
CT1	Biodiversity and Ecosystem Health	Risk	CT1. Assessing the cumulative risks to the success of rehabilitation on-site and to the protection of the off-site environment.	CT1A. What are the cumulative risks to the success of rehabilitation on-site and to the off-site environment?	It is important to assess cumulative risk as examining risks individually does not address the interaction between risks and their iterative effects. An integrated conceptual model will capture the interactions between multiple risks (e.g. landform stability, revegetation and contaminant exposure) and assessment endpoints (receptors). The integrated model and assessment will be continually tested and improved as part of best practice and include outputs from all other KKNs.	BOTH
CT2	World Heritage values	Heritage Values	CT2. Characterising World Heritage values of the Ranger Project Area	CT2A. What World Heritage Values are found on the Ranger Project Area, and how might these influence the incorporation of the site into Kakadu National Park and World Heritage Area?	There are areas within the Ranger Project Area that exhibit World Heritage Values for which Kakadu is listed, and documentation of these may assist decision-makers in incorporating the site into Kakadu National Park once closure has been achieved.	BOTH