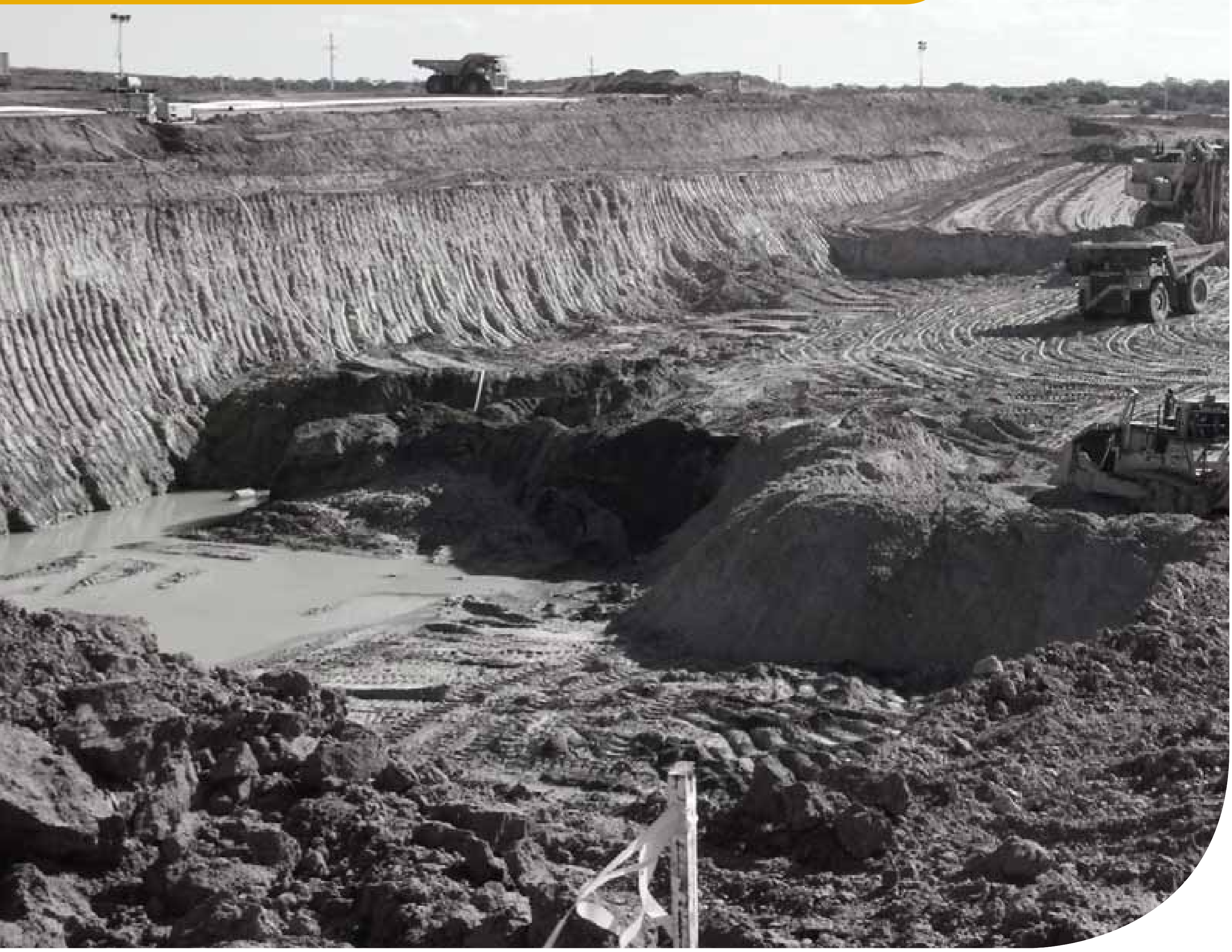
Part B

Environmental impact assessment



8 Assessment approach

8.1 Assessment approach

As with any resource project, the economic viability of mining is inherently sensitive to market conditions and commodity prices. Furthermore, with the scale of mining proposed for the Balranald Project, including both material handling and groundwater management, associated capital and operating costs also affect economic viability. Such sensitivities and costs can affect critical aspects of the Balranald Project; an example of this is overall pit design, with pit dimensions (including width and length) varying depending on product pricing and market conditions. Accordingly, there is a need for ongoing design optimisation depending on market conditions in the lead up to, and over the life of the Balranald Project.

The ongoing process of mine optimisation may result in changes during detailed design, including:

- overall extent (width and length) of the pit within the mining area;
- location and volume of overburden and soil stockpiles within the direct disturbance area;
- location and layout of infrastructure within the processing area;
- location of groundwater dewatering and injection infrastructure;
- location of other infrastructure such as internal haul roads and services infrastructure; and
- avoidance of environmental constraints (eg Aboriginal heritage items, significant vegetation).

As a result, there is a need to provide flexibility in the design of the Balranald Project in any planning approvals. Accordingly, to allow for this flexibility, the adopted environmental impact assessment approach for each technical study is conservative (ie assumed worst case scenarios), providing the ability for some project elements and infrastructure to be relocated within the project area during detailed design.

The approach for the environmental impact assessments considered the principles of avoid, manage, mitigate and offset. That is:

- where attributes with high significance were identified that could be avoided, Iluka revised the project design to avoid impacts to these area by relocating infrastructure (such as internal roads, injection borefields, soil and overburden stockpiles and ancillary infrastructure); and
- where features could not be avoided and would be directly impacted, it was assumed that these would be impacted, and the EIS prepared on this basis with identification of measures to manage, mitigate and offset the impact.

The following chapters provide a summary of the SEARs, existing environment, assessment methods, potential impacts and management and mitigation measures associated with each environmental aspect for the Balranald Project.

8.2 Assessment structure

The SEARs state that detailed assessments of key issues are to include:

- a description of the existing environment likely to be affected by the development, using sufficient baseline data;
- an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant laws, environmental planning instruments, guidelines, policies, plans and industry codes of practice; and
- a description of the measures that would be implemented to mitigate and/or offset the potential impacts of the development, and an assessment of:
    - whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented;
    - the likely effectiveness of these measures;
    - whether contingency plans would be necessary to manage any residual risks; and
- a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved.

Each technical assessment addresses the above requirements where relevant. In particular, the chapters in this EIS summarising the technical assessments have been structured to provide a description of the existing environment, an assessment of the potential impacts of the Balranald Project and a description of the management and mitigation measures that would be implemented by Iluka to ensure residual impacts are addressed. Guidelines, policies and plans relevant to each technical assessment are also addressed.

8.3 Preliminary risk assessment

A qualitative preliminary risk assessment (PRA) was undertaken by EMM and Iluka for the Balranald Project in March 2012, prior to the preparation of the Project Scoping Report. The process adopted included:

- dividing the Balranald Project into components (ie mining areas, processing area, groundwater extraction and injection, access roads and product transport);
- identifying potential environmental risks for each project component;
- identifying scenarios presenting a potential risk to third party users, the environment and/or human health for each key attribute and/or discipline (ie air quality, noise and vibration, groundwater);
- identifying standard environmental controls and mitigation measures for key attributes and/or disciplines;
- determining a consequence and likelihood rating for each identified scenario in the presence of control and/or mitigation measures; and

- assigning a risk rating of low, medium or high based on the determination of the consequence and likelihood rating.

Since the PRA was undertaken in 2012, Iluka has completed both pre-feasibility and detailed feasibility studies. In addition to further project design and development, these studies included further assessments of the surrounding environment including groundwater, biodiversity, geochemistry and Aboriginal Cultural Heritage. These assessments have superseded the outcomes of the PRA and provided a far greater understanding of the environment and how the Balranald Project will interact with it than was originally understood during the PRA. For this reason, the PRA has not been included as it does not accurately reflect the current understanding of risks associated with the Balranald Project as documented in this EIS.

9 Noise and vibration

9.1 Introduction

The SEARs require an assessment of potential noise impacts of the Balranald Project. The SEARs state that this EIS must include:

> an assessment of the likely operational noise impacts of the development (including construction noise) under the NSW Industrial Noise Policy [INP], including the obligations in chapters 8 and 9 of the policy;
>
> if a claim is made for specific construction noise criteria for certain activities, then this claim must be justified and accompanied by an assessment of the likely construction noise impacts of these activities under the Interim Construction Noise Guideline; and
>
> an assessment of the likely road noise impacts of the development under the NSW Road Noise Policy.

The noise assessment for the Balranald Project was prepared by EMM (Appendix D) and the results are summarised in this chapter. The assessment was prepared in accordance with the following regulations, methods and guidance documents as specified in the SEARs:

- *NSW Industrial Noise Policy* (INP) (EPA 2000);
- *NSW Road Noise Policy* (RNP) (EPA 2011);
- *The Interim Construction Noise Guideline* (ICNG) (EPA 2009); and
- *Voluntary Land Acquisition and Mitigation Policy* (VLAMP) (2014).

9.2 Existing environment

To establish representative ambient noise levels in the vicinity of the project area, noise monitoring (unattended and attended) was conducted at the three locations (monitoring locations A, B and C) shown in Figure 9.1. The monitoring locations were selected as being representative of the nearby assessment locations. Noise loggers were installed from 16 July to 1 August 2012 while operator attended measurements were completed on 16 July 2012.

Natural noise sources such as birds and insects where the dominant feature of the background noise levels. A daytime rating background level (RBL) of 31 dB(A) was recorded at monitoring location B; all other periods and monitoring locations recorded an RBL of <30 dB(A) and thus 30 dB(A) has been adopted for assessment locations shown in Figure 9.1. A summary of existing background and ambient noise levels is provided in Table 9.1.

Table 9.1 Summary of existing background and ambient noise levels, dB(A)

Monitoring location	Period	RBL[1]	Measured existing L_{Aeq} noise level[2]	Existing L_{Aeq} industrial contribution
A	Day	<30	41	nil
	Evening	<30	37	nil
	Night	<30	40	nil
B	Day	31	46	nil
	Evening	<30	44	nil
	Night	<30	38	nil
C	Day	<30	43	nil
	Evening	<30	40	nil
	Night	<30	36	nil

Notes: 1. The RBL is an INP term and is used represent the background noise level.
2. The energy averaged noise level over the measurement period and representative of general ambient noise.

9.3 Impact assessment

9.3.1 Noise assessment criteria

i Construction noise

The Balranald Project construction noise assessment criterion was determined in accordance with the ICNG for standard hours. As construction of the Balranald Project is proposed to occur 24 hours per day, the ICNG noise management levels (NMLs) that would apply are provided in Table 9.2.

Table 9.2 Construction noise management level for the project

Assessment location	Time of day	Management level	Measured RBL	Management level $L_{eq,15min}$
Residential	Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm, Saturday 8:00 am to 1:00 pm, No work on Sundays or public holidays	Noise affected	30 dB(A)	40 dB(A)
		Highly noise affected	n/a	75 dB(A)
	Outside recommended standard hours	Noise affected	30 dB(A)	35 dB(A)

The EPA's sleep disturbance criteria of 45 dB(A), L_{max} has also been used to assess construction noise during the night-time period (10:00 pm to 7:00 am Monday to Saturday, and 10:00 pm to 8:00 am on Sundays).

ii Operational noise

Intrusive $L_{Aeq(15minute)}$ and amenity $L_{Aeq(period)}$ criteria for the operational noise assessment were established in accordance with the INP. Project specific noise levels (PSNL) were developed from the more stringent of the intrusive and amenity criteria.

The intrusive criteria is based on the RBL, and dictates that the equivalent continuous noise level (L_{Aeq}) from the source should not exceed 5 dB above the measured RBL. The RBL of 30 dB(A) has been adopted for assessment locations surrounding the project area (Figure 9.1). The amenity criteria are specific to land use and associated activities and are defined in the INP. The criteria only relate to industrial-type noise (including mining) and do not include road, rail or community noise. The intrusive and amenity criteria for the Balranald Project are shown in Table 9.3 together with the PSNL (the more stringent of the amenity and intrusive criteria).

Table 9.3 Operational noise assessment critiera for the Balranald Project

Receptor	Amenity area	Period	Noise level dB(A)			
			RBL	Intrusive criteria, $L_{Aeq,15minute}$	Amenity criteria, $L_{Aeq,period}$	PSNL
All residences	Rural	Day	<30	35	50	35 $L_{Aeq,15minute}$
		Evening	<30	35	45	35 $L_{Aeq,15minute}$
		Night	<30	35	40	35 $L_{Aeq,15minute}$

Note: $L_{Aeq,period}$ is for any given period ie day, evening and night.

iii Land acquisition and mitigation

The NSW Government has developed the *Voluntary Land Acquisition and Mitigation Policy* (VLAMP) (VLAMP 2014). The VLAMP has been formally adopted by the NSW Government and seeks to balance acquisition and mitigation obligations for mining operators that provide appropriate protections for landholders, where impacts related to noise and air quality are significant. The consent authority is required to consider the Voluntary Land Acquisition and Mitigation Policy in determining applications for State significant mining, petroleum and extractive industry projects.

Voluntary mitigation and acquisition rights in the VLAMP are assigned to privately owned dwellings based on the level of predicted noise above the PSNL. This is explained in Table 9.4.

Table 9.4 Characterisation of noise impacts and potential treatments

Residual noise exceedances	Characterisation of impacts	Potential treatment
0-2 dB(A) PSNL	Impacts are considered to be negligible	The exceedances would not be discernable by the average listener and therefore would not warrant receiver based treatments or controls.
3-5 dB(A) above the PSNL in the INP but the development would contribute less than 1 dB to the total industrial noise level	Impacts are considered to be marginal	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
3-5 dB(A) above the PSNL in the INP and the development would contribute more than 1 dB to the total industrial noise level	Impacts are considered to be moderate	As for marginal impacts but also upgraded façade elements like windows, doors, roof insulation etc. to further increase the ability of the building façade to reduce noise levels.
>5 dB(A) above the PSNL in the INP	Impacts are considered to be significant	Provide mitigation as for moderate impacts and see voluntary land acquisition provisions below.

Source: VLAMP 2014.

The impact characterisations that are most likely to apply to the Balranald Project are negligible, moderate and significant as there are generally no existing industrial noise sources surrounding the project area that could trigger the marginal impact characterisation.

The VLAMP provides noise acquisition criteria for privately owned land parcels. The policy assigns acquisition rights if the noise generated by a development contributes to an exceedance of the recommended maximum noise levels in Table 2.1 of the INP on more than 25% of any privately owned land, where a dwelling could be built on the land under existing planning controls.

For the Balranald Project this results in acquisition criteria of 55 dB(A), 50 dB(A) and 45 dB(A) ($L_{eq, period}$) for the day, evening and night periods, respectively, on more than 25% of any privately owned land, whether or not a dwelling is present.

iv Low frequency noise

The INP provides guidelines for applying 'modifying factor' adjustments to account for low frequency noise emissions. Where there is a difference of 15 dB or more between 'C' weighted and 'A' weighted noise levels, then a modifying factor correction of 5 dB is applicable. 'A' weighted noise levels are adjusted to approximate the frequency response of the human ear while 'C' weighted noise levels apply a smaller reduction to lower frequencies and is used to detect low frequency energy from a noise source.

A paper published in Acoustics Australia Vol. 39, April 2011 by Dr Norm Broner entitled *A Simple Outdoor Criterion for Assessment of Low Frequency Noise Emission* (refer to as the Broner approach), suggests that low frequency noise is not likely to result in impacts unless received levels are above 60 dB(C). This simplistic criterion is also commonly applied in low frequency noise assessments.

This noise impact assessment has reviewed low frequency noise against both the INP and the Broner approach.

v Sleep disturbance

Intermittent noises can disturb the sleep of nearby residents. Sleep disturbance screening criterion are provided in the INP application notes, which recommend the maximum noise level from a source should not exceed the existing RBL by more than 15 dB. This criterion applies at the nearest bedroom facade of a dwelling.

This assessment has adopted a sleep disturbance screening criterion of 45 dB(A) L_{max} for all assessment locations, based on an RBL of 30 dB(A).

vi Road noise

The principle guidance used to assess the impact of road traffic noise on private residences is in the RNP. Two road types have been considered in the assessment: freeway/arterial/sub-arterial roads and local roads. The road noise assessment criteria for assessment locations are presented in Table 9.5, reproduced from Table 3 of the RNP.

Table 9.5 Road traffic noise assessment criteria for residential land use

Road category	Type of project/development	Assessment criteria, dB(A)	
		Day (7:00 am to 10:00 pm)	**Night (10:00 pm to 7:00 am)**
Freeway/arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments	$L_{eq(15\text{-}hr)}$ 60 (external)	$L_{eq(9\text{-}hr)}$ 55 (external)
Local roads	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	$L_{eq(1\text{-}hr)}$ 55 (external)	$L_{eq(1\text{-}hr)}$ 50 (external)

The RNP states that where the existing road traffic noise levels exceed the criteria in Table 9.6, any additional increase in total traffic noise level (ie existing and future) should be limited to an additional 2 dB.

In addition to meeting the assessment criteria, any significant increase in total traffic noise at assessment locations must be considered.

Table 9.6 Relative increase criteria for residential land uses

Road Category	Type of project/development	Total traffic noise level increase - dB	
		Day (7:00 am to 10:00 pm)	**Night (10:00 pm to 7:00 am)**
Freeway/arterial/sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{eq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{eq(9\text{-}hr)}$+ 12 dB (external)

Lastly, the RNP also provides guidance on how to treat road category transition zones (eg where an arterial road transitions into a local road). Where this occurs, the RNP recommends that:

- where the existing noise levels are between the lower criteria and the higher criteria, the existing noise levels are the target; or
- where the existing noise levels exceed the higher criterion, the higher criterion is the target.

This is relevant to McCabe Street, Balranald, as it transitions into an arterial road (the Sturt Highway).

9.3.2 Method

Noise modelling was completed using the Brüel and Kjær Predictor Version 8.14 software. The model considers factors such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the project area and surrounding area, and applicable meteorological conditions.

i Meteorological effects

During certain wind conditions, noise levels at assessment locations may increase or decrease compared with noise during calm conditions. This is due to refraction caused by the varying speed of sound with increasing height above ground. The received noise level increases when the wind blows from the source to the receiver and, conversely, decreases when the wind blows from the receiver to the source. Temperature inversions (where atmospheric temperature increases with altitude) typically occur at night in the winter months and can potentially increase mine noise levels at surrounding private residences.

The INP provides a procedure for identifying prevailing wind and temperature inversion meteorological conditions at a site (referred to as a 'feature' of the area) to be used when assessing noise levels against the criteria. According to the INP, winds of up to 3 m/s must be considered in noise predictions when they occur for greater than 30% of the time during day, evening or night periods. Temperature inversions are to be assessed when they are found to occur for 30%, or more, of the time (about two nights per week) during the winter months.

Site specific weather data was provided by Environ, generated using atmospheric modelling software, CALMET for the 2011 calendar year (Refer Appendix D). The 'G' class temperature inversion occurred 37.8% of the time during winter and is a feature of the area. It was therefore considered in the assessment. All wind speeds below 3 m/s were considered further.

The project area and surrounds are generally flat with noise sources typically at a similar elevation to assessment locations. The potential for drainage flows (the flow of noise from a place of elevation) to impact the noise results are considered unlikely and have not been considered further in the assessment.

ii Construction

Noise modelling was undertaken to predict construction noise levels from the Balranald Project. Construction activities (described in Table 5.4 of Appendix D) differ from operational (or mining) activities and therefore have been assessed separately using ICNG noise criteria.

A quantitative noise assessment was undertaken. Activities associated with the development of the initial boxcut (eg removal and stockpiling of topsoil and overburden) have not been considered in the construction noise assessment and are assessed as operational activities (under more stringent criteria).

Construction noise predictions were completed using the Brüel and Kjær Predictor Version 8.14 software. All construction scenarios have been assessed as occurring simultaneously, and therefore represent worst case noise levels throughout the construction phase.

iii Operation

Noise modelling was based on three-dimensional digitised ground contours of the surrounding land, mine pits and overburden emplacement areas for three representative stages of the Balranald Project (Years 1, 4 and 8). The mine plans contain plant and equipment placed at various locations and heights, representing realistic operating conditions. The model assumed all plant and equipment to be operating simultaneously and at maximum sound power levels. In practice, this is unlikely to occur, or would occur infrequently. Therefore, noise predictions are based on worst case operating scenario and are considered to be conservative. Operational activities at West Balranald and Nepean mines have been modelled simultaneously for Year 8 to assess the combined noise emissions at assessment locations.

iv Sensitive receptor assessment locations

The noise assessment catchment was conservatively defined as being 10 km from any noise source. Within this domain, 47 assessment locations were identified. Assessment locations are shown in Figure 9.1. As described in Section 3.9, assessment locations include both habitable and non-habitable built structures.

v Meteorological conditions

A summary of calm and prevailing weather conditions assessed in the noise modelling are provided in Table 9.7, determined in accordance with the INP.

Table 9.7 Relevant site-specific meteorological parameters

Assessment condition	Period	Temperature	Wind speed (m/s)/direction	Relative humidity	Temperature gradient
Calm	Day/evening/night	10°C	Nil	90%	nil
Prevailing winds	Night	10°C	2.4/ESE (112.5°)	90%	nil
			2.6/SE (135°)		
			2.7/SSE (157.5°)		
			2.7/S (180)		
			2.8/SSW (202.5°)		
			2.5/SW (225°)		
			2.5/WSW (247.5°)		
			2.5/W (270°)		
G class temperature inversion	Night	10°C	nil	90%	4/100 m

9.3.3 Results

i Construction noise

The construction noise assessment predicted that the highest noise level from all valid meteorological conditions (calm, prevailing winds and temperature inversion) would exceed the ICNG construction noise criteria at one assessment location (Table 9.8) during any of the eight construction scenarios. For all other assessment locations, construction noise levels are predicted to comply with the ICNG criteria.

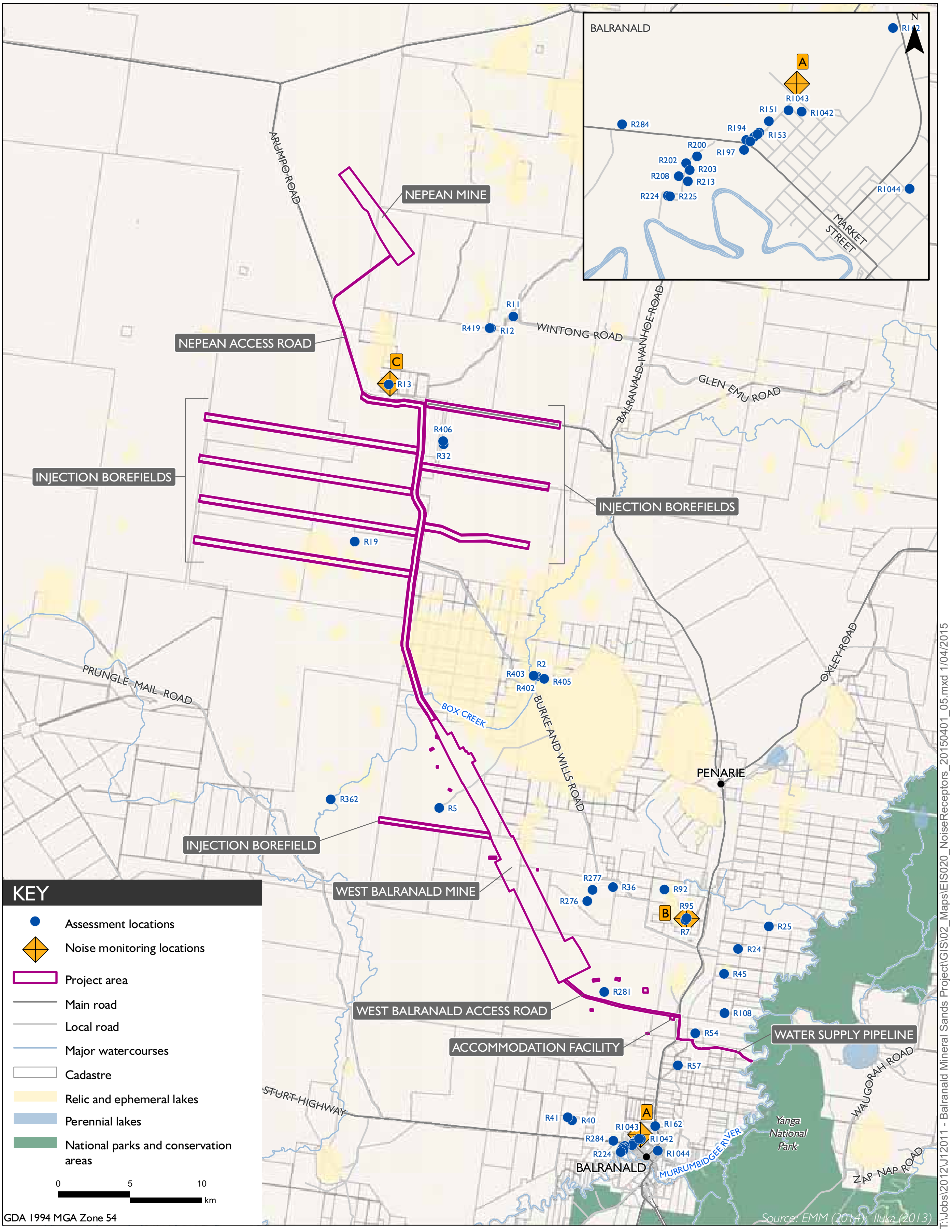
Table 9.8 Predicted 24 hour construction noise levels, dB(A)

Assessment location ID	Construction scenario (from Table 5.4) predicted noise level, $L_{eq,15min}$								Total $L_{eq,15min}$ noise level[1]	NML, $L_{eq,15min}$	
	1	2	3	4	5	6	7	8		Standard Hours	OOH
R13	<30	<30	<30	<30	<30	**38**	<30	<30	**38**	40	35

Notes: 1. Total noise level from simultaneous construction of scenarios 1 to 8.

2. OOH = out of hours.

3. Bold indicates exceedance of standard NML, highlight indicates exceedance of OOH NML.



Assessment locations and noise monitoring locations

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Figure 9.1

The closest construction activity modelled near R13 is the construction of the Nepean access road. Given the nature of road construction, it is expected that noise impacts would be short term. Noise management measures to minimise construction noise impacts on the assessment locations are provided in Section 9.4.

Predicted maximum noise levels during the night time period are provided in Table 9.9. These demonstrate that noise from the Balranald Project would satisfy the EPA's strict sleep disturbance criteria at all but one assessment location (R13).

Table 9.9 Predicted maximum construction noise levels where criteria are exceeded, dB(A)

Assessment location ID	Construction scenario and predicted noise level, $L_{eq,15min}$ (dB(A))[2]								Maximum noise level, all scenarios[1]	Night time Sleep disturbance noise criteria, L_{max}
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**		
13	<30	15	<30	<30	<30	**46**	<30	<30	**46**	45

Notes: 1. Maximum predicted noise level from scenarios 1 to 8.
2. Bold indicates exceedance of sleep disturbance criteria.

It is anticipated that construction noise could be managed appropriately to below ICNG construction noise criteria and sleep disturbance criteria which is discussed further in Section 9.4.1.

ii Operational noise

a. Impacts at assessment locations

Assessment locations at which noise levels are predicted to be greater than the PSNL of 30 dB(A), $L_{Aeq,15minute}$ are shown in Table 9.10. Predicted noise levels at assessment locations for all meteorological conditions are provided in Table 6.1 of Appendix D.

The grey, red and blue shading indicates assessment locations where noise predictions fall into negligible (1 to 2 dB above PSNL), moderate (3 to 5 dB above PSNL) or significant (greater than 5 dB above PSNL) noise impact characterisations (respectively) as described in the VLAMP. Noise levels at all other assessment locations were predicted to be less than 30 dB(A), $L_{Aeq,15minute}$.

The PSNL and voluntary acquisition noise level trigger do not apply for assessment locations R276, R277 and R281 as these assessment locations are not dwellings, and have been identified as sheds, while R5 is an uninhabited dwelling.

Table 9.10 Predicted operational noise levels at assessment locations during calm, prevailing and temperature inversion meteorology - dB(A), $L_{eq(15-min)}$

Year and assessment location ID	Day	Night			PSNL
	Calm	Calm	Winds	Inversion	
Year 1					
R5 [1]	<30	<30	<30	<30	35
R36[2]	30	31	37	37	35
R276 [2]	37	39	44	44	n/a
R277 [2]	34	35	42	41	n/a
R281 [2]	<30	<30	36	37	n/a
Year 4					
R5 [1]	35	38	45	46	35
R36	<30	<30	<30	<30	35
R276 [2]	<30	<30	32	32	n/a
R277 [2]	<30	<30	<30	30	n/a
R281 [2]	<30	<30	<30	<30	n/a
Year 8					
R5 [1]	<30	<30	36	37	35
R36	<30	<30	35	34	35
R276 [2]	30	31	42	41	n/a
R277 [2]	<30	<30	38	38	n/a
R281 [2]	31	33	42	43	n/a

Notes: *1. Assessment location is currently uninhabited.*

2. Assessment location is not a dwelling and therefore the PSNL does not apply.

Figure 9.2 shows the highest predicted noise levels at all assessment locations combined for all modelled years under all assessed meteorological conditions.

The noise model predictions have been assessed by comparing the higher of the calm, winds and temperature inversion results to the INP criteria. Assessment locations predicted with negligible, moderate or significant noise impacts are presented in Table 9.11. Note that those assessment locations identified as sheds have been excluded.

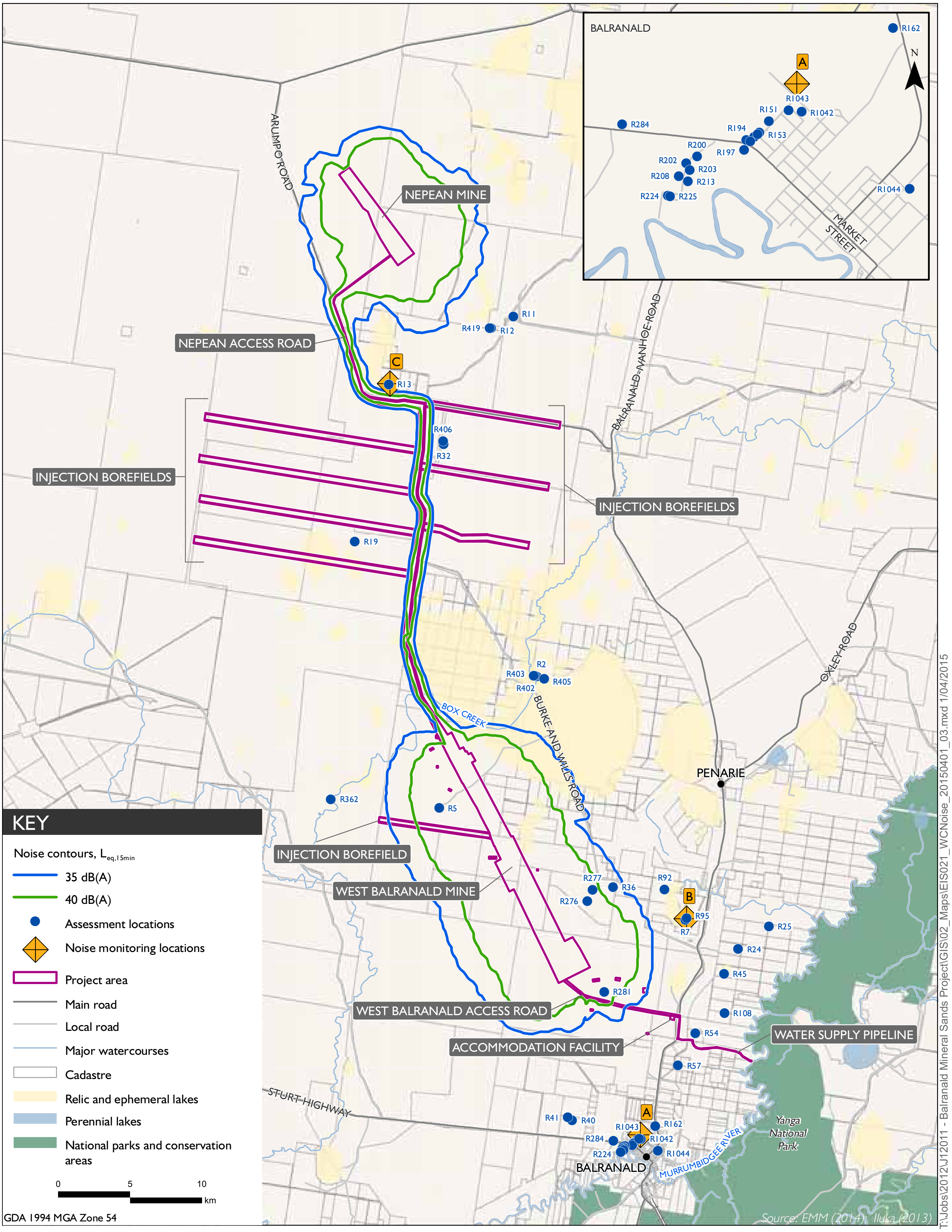
Table 9.11 Characterisation of impacts where predicted noise levels are above PSNL, adverse weather conditions, all years

Negligible (1 to 2 dB above PSNL)	Moderate (3 to 5 dB above PSNL)[1]	Significant (>5 dB above PSNL)[2]
Nil	Nil	R5

Notes: *1. Assessment locations entitled to voluntary noise mitigation in the form of mechanical ventilation / comfort condition systems and upgraded facade elements to reduce internal noise levels under the VLAMP 2014.*

2. Assessment locations entitled to voluntary acquisition under the VLAMP 2014.

During adverse weather conditions for all assessment periods, for all stages of the mining life, one assessment locations (R5) within the area modelled is predicted to experience noise levels above the PSNL (ie>35 dB(A)). This location is predicted to experience significant noise (>5 dB above PSNL) during Year 4. At other times predicted noise levels at this location are either below the PSNL (Year 1) or marginally above the PSNL (Year 8). Nonetheless, the significant noise impact predicted in Year 4 entitles R5 to voluntary acquisition upon request in accordance with the VLAMP. It is understood that the dwelling at this assessment location is currently uninhabited.



EMM ILUKA

Worst case noise levels (all years)

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 9.2

b. Privately owned land

Two properties, Pine Lodge and Hughdale, would experience exceedances of criteria on more than 25% of their property area (see Figure 9.3), which would trigger voluntary acquisition rights upon request for these properties in accordance with the VLAMP. However, given these properties are partially located within the project area all of the affected land will be subject to purchase or land access agreements irrespective of the noise assessment.

iii Low frequency noise

An assessment was undertaken to quantify low frequency noise impacts. C-weighted noise levels at assessment locations have been calculated by applying the octave band C-weightings to the predicted octave band noise levels.

The assessment has been limited to assessment locations (shown in Table 9.12) with predicted operational noise levels greater than 30 dB(A), as the 5 dB penalty (if low frequency noise was identified), would not lead to noise levels over the 35 dB(A) PSNL at these assessment locations. Noise levels were predicted during prevailing winds and temperature inversions as these conditions provided the greatest noise levels at surrounding assessment locations. Results of the assessment are provided in Table 9.12. The grey text boxes denote a difference between dB(A) and dB(C) noise levels of greater than 15 dB.

Table 9.12 Predicted operational low frequency noise levels, $L_{eq,(15min)}$

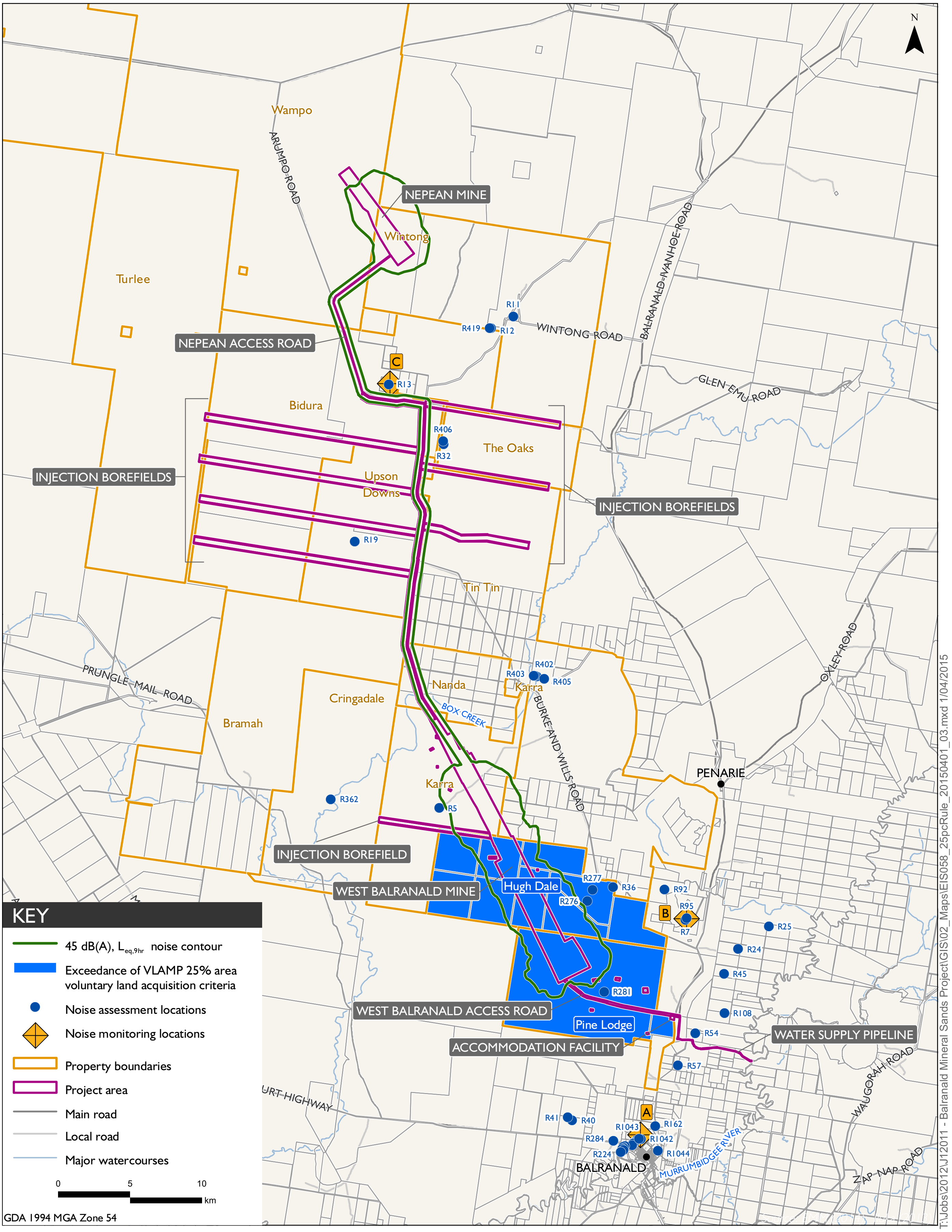
Assessment location ID	Year 1			Year 4			Year 8		
	dB(A)	dB(C)	A-C	dB(A)	dB(C)	A-C	dB(A)	dB(C)	A-C
R5	<30	n/a	n/a	46	55	**9**	37	50	13
R36[1]	37	51	14	<30	n/a	n/a	35	48	13
R276[1]	44	56	12	32	54	22	42	52	10
R277[1]	42	55	13	30	52	22	38	51	13
R281[1]	37	49	12	<30	n/a	n/a	43	51	8
Criteria	**35**	**60**	**≥15**	**35**	**60**	**≥15**	**35**	**60**	**≥15**

Notes: 1. These assessment locations have been identified as sheds.

n/a - denotes predicted dB(A) noise levels below 30 where a low frequency adjustment would not cause an penalty corrected noise level over the PSNL.

The low frequency noise levels (dB(C)) at all assessment locations would remain below 60 dB(C) Broner criterion.

For R276 and R277, the difference between dB(A) and dB(C) noise levels is greater than 15 dB. Notwithstanding, the difference between the dB(A) and dB(C) sound power levels for all plant and equipment (refer to Appendix C of Appendix D) is less than 15 dB. It is therefore considered unduly stringent for all plant and equipment to be subject to a 5 dB 'modifying factor' adjustment, given also that the absolute dB(C) noise level is well below what is considered to cause adverse low frequency noise impacts, as discussed in the 'Broner' technical paper. Furthermore, R276, R277 and R281 have been identified as sheds, and therefore, potential low frequency noise impacts do not apply.



Privately owned land assessment - Worst case noise levels, all years, all assessed meteorological conditions, $L_{eq(9\text{-}hr)}$ dB(A)

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Figure 9.3

iv Sleep disturbance criteria

Maximum noise levels from the project area are expected to be below the 45 dB(A) noise criterion at all assessment locations during calm and adverse meteorological conditions. Predicted maximum noise levels for the night-time period during calm and adverse meteorological conditions are provided in Table 9.13. Predictions shown are limited to assessment locations with L_{max} noise levels over 30 dB(A). Noise levels at the remaining assessment locations are predicted to be below this threshold and are not presented in Table 9.13.

Table 9.13 Maximum noise from intermittent sources at assessment locations, dB(A)

Assessment location ID	Modelled L_{max} night time noise level									L_{max} criterion
	Year 1			Year 4			Year 8			
	Calm	Winds	Inversion	Calm	Winds	Inversion	Calm	Winds	Inversion	
R5	< 30	< 30	< 30	36	40	42	< 30	37	38	45
R36	< 30	34	34	< 30	< 30	< 30	< 30	31	31	45
R276[1]	37	41	41	< 30	< 30	< 30	< 30	40	40	n/a
R277[1]	34	39	38	< 30	< 30	< 30	< 30	37	36	n/a
R281[1]	< 30	32	33	< 30	< 30	< 30	33	40	41	n/a

Notes: 1. These assessment locations have been identified as sheds.

v Road traffic noise

a. Construction traffic

Construction traffic volumes are detailed in Chapter 18. The majority of road traffic movements associated with construction have been assumed to occur between 6:00 am to 7:00 pm. The period between 6:00 pm to 7:00 pm would fall within the RNP night-time period and would therefore present the worst case assessment period for the Balranald Project.

Calculation of road traffic noise levels for this period are provided in Table 9.14, which include the same assumptions relating to road category and criteria as the operational road traffic noise assessment.

Table 9.14 Construction road traffic noise levels (2018), night-time, dB(A)

Road	Distance to nearest assessment location	Existing traffic		Balranald Project traffic[5]		Total traffic noise level	Change from existing traffic noise level	Night time criteria
		Cars (HV[1])	Noise Level	Cars (HV[1])	Noise Level			
Balranald Ivanhoe Rd[3]	55 m	69 (18)	46 $L_{eq,9hr}$	50 (65)	50 $L_{eq,9hr}$	51 $L_{eq,9hr}$	5	55 $L_{eq,9hr}$
Sturt Highway (Euston)[3]	35 m	162 (83)	55 $L_{eq,9hr}$	18 (10)	45 $L_{eq,9hr}$	55 $L_{eq,9hr}$	0	55 $L_{eq,9hr}$
Balranald Tooleybuc Rd (Southern section)[3]	40 m	48 (15)	47 $L_{eq,9hr}$	5 (46)	49 $L_{eq,9hr}$	51 $L_{eq,9hr}$	4	55 $L_{eq,9hr}$
Balranald Tooleybuc Rd (at Tooleybuc Bridge)[3]	20 m	134 (30)	50 $L_{eq,9hr}$	5 (46)	50 $L_{eq,9hr}$	53 $L_{eq,9hr}$	3	55 $L_{eq,9hr}$

Table 9.14 Construction road traffic noise levels (2018), night-time, dB(A)

Road	Distance to nearest assessment location	Existing traffic		Balranald Project traffic[5]		Total traffic noise level	Change from existing traffic noise level	Night time criteria
		Cars (HV[1])	Noise Level	Cars (HV[1])	Noise Level			
Mayall Street[3]	15 m	113 (13)	49 $L_{eq,9hr}$	22 (6)	45 $L_{eq,9hr}$	50 $L_{eq,9hr}$	1	55 $L_{eq,9hr}$
Piper St[4]	25 m	2 (2)	47 $L_{eq,1hr}$	0 (3)	47 $L_{eq,1hr}$	50 $L_{eq,9hr}$	3	50 $L_{eq,1hr}$
McCabe St[3]	15 m	14 (10)	45 $L_{eq,9hr}$	9 (48)	52 $L_{eq,9hr}$	53 $L_{eq,9hr}$	8	55 $L_{eq,9hr}$
Market St[3]	15 m	398 (90)	53 $L_{eq,9hr}$	7 (2)	36 $L_{eq,9hr}$	53 $L_{eq,9hr}$	0	55 $L_{eq,9hr}$
Total at the corner of McCabe and Market St	-	-	54 $L_{eq,9hr}$	-	52 $L_{eq,9hr}$	56 $L_{eq,9hr}$	2	55 $L_{eq,9hr}$

Notes: *1. HV = heavy vehicles.*

2. Bold text denotes exceedance of RNP noise criteria.

3. Existing night-time hourly traffic is based 15% of AADT. Proposed Light and heavy vehicles are assumed to be distributed evenly.

4. Existing hourly peak traffic is based on tube counts projected for year 2020 and assume proposed traffic from other mines. Proposed hourly peak traffic assumes 50% of all predicted light vehicle traffic and 10% of all predicted heavy vehicle traffic occur during peak hour.

5. Balranald Project traffic only.

Predicted road traffic noise levels satisfy the RNP noise criteria at all nearest assessment locations for all assessed roads.

Total predicted road traffic noise levels at the nearest assessment location on the corner of McCabe Street and Market Street are within 2 dB of existing levels and therefore within RNP noise guidelines.

b. Operational traffic

Operational traffic generation is detailed in Chapter 18. The operational traffic noise assessment has assumed product haulage traffic movements are distributed over a 24 hour period. Employee traffic movements have been assumed to occur in a peak hour period coinciding with a project shift changeover, expected to occur daily between 6:00 am to 7:00 am. This provides a conservative assessment, as peak traffic volumes during this time would fall into the night time assessment period where a more stringent criterion applies.

Table 9.15 presents predicted existing and project related road traffic noise levels to nearest assessment locations to each road. Predictions have been provided for the night time as this presents the worst case period for potential project related traffic noise impacts.

Table 9.15 Operational road traffic noise levels (Year 4), night-time, dB(A)

Road	Distance to nearest assessment location	Existing traffic		Balranald Project traffic[5]		Total traffic noise level	Change from existing traffic noise level	Night time criteria
		Cars (HV[1])	Noise Level	Cars (HV[1])	Noise Level			
Balranald-Ivanhoe Rd[3]	55 m	68 (18)	46 $L_{eq,9hr}$	57 (76)	50 $L_{eq,9hr}$	51 $L_{eq,9hr}$	5	55 $L_{eq,9hr}$
Balranald Tooleybuc Rd (Southern section)[3]	40 m	51 (16)	47 $L_{eq,9hr}$	6 (58)	50 $L_{eq,9hr}$	54 $L_{eq,9hr}$	7	55 $L_{eq,9hr}$
Balranald Tooleybuc Rd (at Tooleybuc Bridge)[3]	20 m	140 (31)	50 $L_{eq,9hr}$	6 (58)	51 $L_{eq,9hr}$	54 $L_{eq,9hr}$	4	55 $L_{eq,9hr}$
Mayall Street[3]	15 m	119 (13)	49 $L_{eq,9hr}$	23 (6)	45 $L_{eq,9hr}$	50 $L_{eq,9hr}$	1	55 $L_{eq,9hr}$
Piper St[4]	25 m	3 (2)	45 $L_{eq,1hr}$	0 (2)	45 $L_{eq,1hr}$	48 $L_{eq,9hr}$	3	50 $L_{eq,1hr}$
McCabe St[3]	15 m	15 (10)	45 $L_{eq,9hr}$	11 (60)	53 $L_{eq,9hr}$	53 $L_{eq,9hr}$	8	55 $L_{eq,9hr}$
Market St[3]	15 m	413 (94)	53 $L_{eq,9hr}$	8 (2)	36 $L_{eq,9hr}$	53 $L_{eq,9hr}$	0	55 $L_{eq,9hr}$
Total at the corner of McCabe and Market St (west facade)	-	-	54 $L_{eq,9hr}$	-	53 $L_{eq,9hr}$	56 $L_{eq,9hr}$	2	55 $L_{eq,9hr}$

Notes: *1. HV = heavy vehicles.*

2. Bold text denotes exceedance of RNP noise criteria.

3. Existing night-time traffic is based 15% of AADT. Proposed Light and heavy vehicles are assumed to be distributed evenly over 24 hours.

4. Existing hourly peak traffic is based on tube counts projected for year 4 and assume proposed traffic from other mines. Proposed hourly peak traffic assumes 50% of all predicted light vehicle traffic and 10% of all predicted heavy vehicle traffic occur during peak hour.

5. Balranald Project traffic only.

Predicted road traffic noise levels satisfy the RNP noise criteria at all nearest assessment locations to all assessed roads.

Total predicted road traffic noise levels at the nearest assessment location on the corner of McCabe Street and Market Street are within 2 dB of existing levels and therefore within RNP noise guidelines.

9.4 Management and mitigation

9.4.1 Construction

A construction environmental management plan (CEMP) that addresses noise and vibration management and mitigation options (where required) would be completed prior to the commencement of construction. The main objective would be to ensure that as far as practicable construction activities meet construction ICNG NMLs across the proposed 24 hour construction period.

The CEMP would describe how construction noise levels (including traffic) would be managed at assessment locations where predicted noise levels above the NMLs have been identified (ie assessment location R13) as follows:

- Measure construction noise levels at early stages of construction to validate the predicted construction noise levels.
- Re-evaluate the predicted construction noise levels at assessment locations.
- Re-evaluate the predicted construction noise levels near the Nepean access road, and where required review noise management and mitigation measures to reduce levels below the NMLs. This may include but is not limited to:
    - limiting Nepean access road construction within a certain distance of assessment locations during the evening and night time period;
    - selecting quieter equipment or reduced equipment fleet during the evening and night period; or
    - measuring construction noise levels at assessment locations during the evening and night-time period and implementing real-time noise management and mitigation measures where exceedance of NMLs is identified.

Affected property owners would be consulted prior to and during construction where exceedance of NMLs has been predicted, and would be notified of proposed mitigation measures that would be used to manage construction noise levels to below ICNG NMLs.

Iluka would also seek to redirect the majority of heavy vehicles travelling from the east to use the Sturt Highway and McCabe Street to minimise potential noise impacts to residential areas during construction.

9.4.2 Operations

There is one assessment location (R5) predicted to experience noise levels above the PSNL. This assessment location will be entitled to acquisition rights upon request due to predicted noise levels 5 dB above the PSNL predicted during Year 5. At other times predicted noise levels at this location are either below the PSNL (Year 1) or marginally above the PSNL (Year 8).

The noise management plan would provide management and mitigation measures and detail activities to manage noise emissions from operations (including traffic). The noise management plan would (as may be required):

- identify noise affected properties consistent with the environmental assessment and any subsequent assessments;
- outline mitigation measures to achieve the noise limits established;
- schedule heavy vehicle movements during least sensitive times of day (7:00 am to 10:00 pm);
- minimise heavy vehicle engine brake noise when passing residential areas, especially areas that are relatively highly populated (eg Balranald Town);

- outline measures to reduce the impact of intermittent, low frequency and tonal noise (including truck reversing alarms using broadband quakers);
- specify measures to document any higher level of impacts or patterns of temperature inversions, and detail actions to quantify and ameliorate enhanced impacts if they occur;
- specify protocols for routine, regular attended and unattended noise monitoring of the Balranald Project, including provision for regular low frequency noise monitoring;
- outline the procedure to notify property owners and occupiers that could be affected by noise from the mine and product haulage;
- establish a protocol to handle noise complaints that includes recording, reporting and acting on complaints;
- specify procedures for undertaking independent noise investigations; and
- describe proactive and predictive modelling, and management protocols for managing noise during adverse meteorological conditions.

Iluka would also seek to redirect the majority of heavy vehicles travelling from the east to use the Sturt Highway and McCabe Street to minimise potential noise impacts to residential areas during operations.

9.5 Conclusion

The noise assessment has taken into account the relevant policies and guidelines to satisfy the SEARs. Both unattended long-term and attended noise monitoring was undertaken at representative locations surrounding the project area to characterise the existing noise environment.

Modelling results predict that during adverse weather conditions for all assessment periods and all stages of the mine life, two assessment locations (confirmed as dwellings) are predicted to experience noise levels above the PSNL of 35 dB(A). Of these, one (R5) is predicted to experience significant noise level impacts of greater than 40 dB(A). Assessment locations where significant impacts (ie greater than 40 dB(A)) are predicted are entitled to voluntary acquisition upon request in accordance with the VLAMP.

The privately owned land assessment identified two land parcels in the affected zone. However, the project area covers the majority of the two land parcels and it is therefore expected most of this land would be subject to compensation agreements irrespective of the noise assessment.

The low frequency assessment identified that all assessment locations satisfy the 60 dB(C) Broner low frequency noise criteria. Potential sleep disturbance impacts from operational maximum noise level events have been assessed and are expected to satisfy the relevant criteria for all assessment locations.

The construction noise assessment demonstrates that all assessment locations satisfy the ICNG noise management levels and sleep disturbance criteria, with the exception of assessment location R13, due to the Nepean access road construction. It is expected that, with appropriate management and mitigation, noise levels can be managed to below the ICNG NMLs during the construction period.

Predicted operational and construction road traffic noise levels satisfy RNP noise criteria and guidelines at all nearest assessment locations for all assessed roads.

10 Air quality

10.1 Introduction

The SEARs require an assessment of the potential impacts on air quality due to the Balranald Project. The SEARs require an assessment of air quality including:

> an assessment of the likely air quality impacts of the development in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW and the EPA's additional requirements;
>
> reasonable and feasible mitigation measures to minimise dust and processing emissions, including evidence that there are no such measures available other than those proposed; and
>
> monitoring and management measures, in particular air quality monitoring.

An air quality assessment was undertaken by Environ for the Balranald Project. The air quality assessment was completed in accordance with the *Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales* (DEC 2005) (the Approved Methods) and the EPA's additional requirements attached to the SEARs as specified.

This chapter is a summary of the assessment provided in Appendix E.

10.2 Existing environment

10.2.1 Meteorology

Meteorological conditions govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability. Site-specific meteorological monitoring data was not available for the project area. Site-representative hourly meteorological data was therefore generated through meteorological modelling in accordance with the Approved Methods.

Meteorological modelling was undertaken using the TAPM and CALMET models. It was determined that a modelling approach comprising the input of TAPM-generated data together with hourly observations from the BoM automatic weather station at Mildura Airport into regional CALMET meteorological model would provide the most accurate representation of meteorological conditions at the project area. This method is termed the CALMET Hybrid modelling method. More detailed information on the meteorological and dispersion modelling conducted for the Balranald Project is provided in Appendix H of the air quality assessment in Appendix E.

10.2.2 Prevailing wind regime

Winds in the project area are predominantly south-easterly to south-westerly in summer and autumn while more south-south-westerly to northerly winds are dominant during winter. West-south-westerly to southerly flows are dominant in spring. Southerly winds prevail over the project area with stronger, less frequent westerly and north-north-easterly winds present.

10.2.3 Ambient Temperature

Monthly mean minimum temperatures in the region are in the range of 3.5°C to 16.4°C, with mean maximum temperatures of 16°C to 33°C. Peaks occur during summer months with the highest temperatures typically being recorded between November and February. The lowest temperatures are usually recorded between June and August.

10.2.4 Rainfall and evaporation

The region is classified as a winter rainfall zone with a wet winter and low summer rainfall. The long term average annual rainfall is 324 mm, with ranges between 120 mm and 690 mm. Rainfall is typically higher between May and October. The number of rain days per month ranges between three and eight days (BoM 2013).

10.2.5 Existing pollutant emission sources

A review of the National Pollutant Inventory (NPI) and EPA EPL databases was undertaken to identify any significant existing sources of air pollutants in the surrounding area. Existing sources of emissions and particulate matter situated within 100 km of the project area include Balranald Gypsum Pty Ltd's White Plains Gypsum, Paxtons Mine Lease and Norm's Mine and Brendan Patrick Coates' Glen Avon cattle, sheep or horse station.

Given the rural setting of the project area, other potential sources of atmospheric emissions also include:

- dust entrainment due to vehicle movements along unsealed and sealed roads with high silt loading levels;
- wind-blown dust from open (scalded or eroded) areas;
- agricultural activities;
- vehicle exhaust;
- episodic emissions from vegetation fires; and
- frequent dust storms characteristic of the local area.

10.2.6 Baseline air quality monitoring

No ambient air quality monitoring data was available for the project area to characterise existing air quality. The Approved Methods recognises that site-specific monitoring data is not always available and advises the use of data from monitoring sites where the sources of air pollution are similar to that of the project area.

In the absence of site specific air quality monitoring data, the following sources of information were used to inform the baseline air quality characterisation:

- regional dust storm index (DSI) maps;
- industry monitoring data (particulate matter with an aerodynamic diameter less than 10 micrometers (PM_{10}) and dust deposition) for the Bemax Broken Hill MSP;
- industry monitoring data (dust deposition) for Iluka's WRP mine;
- total suspended particulate (TSP) concentrations measured by CBH Resources at Rasp mine, Broken Hill;
- OEH monitoring data at Albury (PM_{10}) and Wagga Wagga (PM_{10} and particulate matter with an aerodynamic diameter less than 2.5 micrometers ($PM_{2.5}$)); and
- historical monitoring data (PM_{10}) collected by Victoria EPA at Mildura.

i Dust storm index

The DSI is a continental scale measure of the frequency and intensity of wind erosion activity, based on observations of visibility made at BoM stations.

The Balranald Project is located within the Murray Darling Depression region and has an average DSI of 4.9, indicating a moderate potential for dust storm occurrence which would contribute to background particulate matter concentrations within the region.

ii PM_{10}

The closest available PM_{10} monitoring data to the project area is the Victoria EPA station at Mildura, located approximately 135 km from the southernmost extent of the project area. Monitoring for PM_{10} is also conducted at the Bemax MSP, approximately 350 km north-west, at the OEH Albury station, approximately 340 km south-east and the OEH Wagga Wagga station approximately 330 km south-east. The period average PM_{10} concentrations range from 16.7 $\mu g/m^3$ to 28.0 $\mu g/m^3$ across the different sites.

The sites with the most continuous annual PM_{10} data are Broken Hill (Bemax MSP) and Albury (OEH station). The Broken Hill site is considered to provide a conservative estimate of background PM_{10} concentration for the Balranald Project as it is located in a similarly arid area. An annual average background PM_{10} concentration of 18.0 $\mu g/m^3$ has therefore adopted for use in the assessment.

iii $PM_{2.5}$

Rural NSW has limited $PM_{2.5}$ monitoring data available. OEH currently operates 17 stations where simultaneous concentrations of PM_{10} and $PM_{2.5}$ are recorded. The ratio of $PM_{2.5}$ to PM_{10} at these sites varies from 0.29 to 0.45 (with an average ratio of 0.36).

Despite the area surrounding the project area likely having a larger PM_{10} component derived from crustal sources (as opposed to, for example, areas with wood heaters) the average $PM_{2.5}$ to PM_{10} ratio across all OEH monitoring sites has been applied for a more conservative estimate. This resulted in an annual average concentration of 6.5 $\mu g/m^3$.

iv Total suspended particles

No ambient TSP concentration data is available for the project area. However, TSP concentrations are measured at the Rasp Mine in Broken Hill. A PM_{10}/TSP ratio of 0.47 has been derived by ENVIRON comparing PM_{10} data from Bemax MSP and TSP data from the Rasp Mine. In recent years, CBH Resources have measured both PM_{10} and TSP at the Rasp Mine and found the average PM_{10}/TSP ratio for 2010 to 2013 to be 0.41 (CBH, 2013).

Applying this ratio to the PM_{10} concentration data for Broken Hill, an annual average TSP concentration of 43.8 µg/m^3 is derived for background, representing approximately 50% of the impact assessment criterion for TSP.

v Dust deposition

No dust deposition monitoring has been undertaken at the project area. However, dust deposition monitoring has been undertaken at Iluka's WRP mine in Victoria. Based on data recorded during 2010 and 2011, annual average dust rates were found to vary between 0.5 and 2.1 g/m^2/month across sampling sites, with spatially-averaged annual average dust deposition rates calculated to be 0.8 and 1.5 g/m^2/month for 2010 and 2011 respectively. For the purpose of this assessment, a spatially and temporally averaged value of 1.1g/m^2/month was applied.

vi Lead

Background lead concentrations in ambient air have been declining significantly since lead was phased out of petrol in 2002. All six monitoring stations in NSW have been decommissioned and no ambient monitoring has been undertaken since 2005.

By 2004, annual average lead concentrations throughout NSW had decreased to typically less than 0.03µg/m^3 (well below the criterion of 0.5µg/m^3), and many 24-hour average concentrations were below the minimum detection limit (OEH, 2010).

vii Respirable crystalline silica

Very little monitoring data are available for ambient RCS concentrations in NSW. Morrison & Nelson (2011) reported ambient RCS levels in the Hunter Valley region in the range 0.2 to 1.4 µg/m^3 (for $PM_{2.5}$), based on averaging periods of between one hour and five days. Data collected in Victoria estimated background concentrations of 0.7 µg/m^3, while in California a value of 0.6 µg/m^3 was measured at a rural site and 0.2 µg/m^3 at a remote site. The annual average background would be expected to be in the in the lower range of these measurements (0.2 µg/m^3). To be conservative, a value of 0.7 µg/m^3 was assumed as indicative of background concentrations in the project area for the purpose of the cumulative impact assessment (refer Appendix E).

10.3 Impact assessment

10.3.1 Air quality assessment criteria

In NSW, proposed developments generally must demonstrate that cumulative air pollutant concentrations and dust deposition levels would be within OEH ambient air quality criteria at applicable assessment locations (DEC 2005). For some pollutants, there are no OEH air quality criteria and in these cases, reference has been made to standards published by other jurisdictions. Criteria relevant to the Balranald Project are described below.

i Particulate matter

Table 10.1 lists the criteria used for assessment of impacts from particulate matter, including TSP, PM_{10} and $PM_{2.5}$. It should be noted that the criteria for $PM_{2.5}$ is an advisory reporting goal issued by National Environmental Protection Council (NEPC), and has not been adopted by OEH for impact assessment purposes.

The EPA 24-hour PM_{10} assessment criterion of 50 µg/m^3 is numerically identical to the National Environmental Protection Measures (NEPM) air quality standard except that the NEPM standard allows up to five exceedances per year. No provision is made for allowable exceedances of the 24-hour criterion in NSW regulation. The EPA PM_{10} 24-hour and annual average impact assessment criteria were used to assess air quality impacts for the Balranald Project.

The NEPM annual average advisory reporting level for $PM_{2.5}$ (8 µg/m^3) is more stringent that the annual average $PM_{2.5}$ standards promulgated by other jurisdictions. The target level is also lower than the United States Environmental Protection Agency (USEPA) standard (12 µg/m^3) and the current World Health Organisation (WHO) guideline (10 µg/m^3).

The NEPM 24-hour average advisory reporting level for $PM_{2.5}$ (25 µg/m^3) is equivalent to the WHO guideline value but is more stringent that the 24-hour $PM_{2.5}$ standard promulgated by the USEPA (35 µg/m^3). For the purposes of this study, reference has been made to WHO guidelines, to provide a basis for evaluating cumulative 24-hour and annual average $PM_{2.5}$ concentrations due to the Balranald Project.

Table 10.1 Impact assessment criteria – particulate matter

Pollutant	Criteria (µg/m^3)	Averaging period	Agency
TSP	90	Annual cumulative	EPA(a)
PM_{10}	50	24 hour maximum cumulative	EPA(a)
	50(c)	24 hour maximum cumulative(c)	NEPC(b)
	30	Annual cumulative	EPA(a)
$PM_{2.5}$	25	24 hour maximum cumulative	WHO(d)
	25	24 hour maximum cumulative	NEPC(b)(e)
	10	Annual cumulative	WHO(d)
	8	Annual cumulative	NEPC(b)(e)

Notes: *(a) DEC, 2005 Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.*

(b) NEPC, 2003, National Environment Protection (Ambient Air Quality) Measure, as amended.

(c) Provision made for up to five exceedances of the limit per year.

(d) Guideline values issued by WHO.

(e) NEPM advisory reporting levels.

ii Dust deposition criteria

Nuisance dust deposition is regulated through the stipulation of maximum permissible dust deposition rates. Dust deposition criteria as adopted by EPA are summarised in Table 10.2. Maximum incremental dust level of 2 g/m^2/month is applicable for contributions from the Balranald Project alone, and a cumulative dust level of 4 g/m^2/month is applicable for cumulative (Balranald Project plus background concentrations) deposition rates.

Table 10.2 Impact assessment criteria – deposited dust

Pollutant	Maximum Increase	Maximum cumulative	Agency
Deposited dust (g/m^2/month)	2	4	EPA

iii Toxic air pollutants

The air quality criteria for trace metal/metalloids given within the Approved Methods are generally applicable to incremental 99.9th percentile hourly concentrations. Air quality criteria for lead and RCS are however applicable to cumulative annual average concentrations at assessment locations. The annual average criterion for lead is 0.5 µg/m^3. Given that no NSW air quality criterion is published for RCS, reference was made to the Victorian EPA annual average criterion of 3 µg/m^3.

The processing plant for the Balranald Project would be required to meet standards of concentration set out in the NSW *Protection of the Environment Operations (Clean Air) Regulation 2010*. This regulation sets standards for various activities and those that are applicable to the Balranald Project include a solid particle limit of 50 mg/Nm^3 and a NO_x limit of 350 mg/Nm^3.

iv Land acquisition and mitigation

On 19 December 2014 the *Voluntary Land Acquisition and Mitigation Policy* was published by the Minister for Planning in the Government Gazette The *Voluntary Land Acquisition and Mitigation Policy* describes the voluntary mitigation and land acquisition policy to address dust (and noise) impacts and outlines mitigation and acquisition criteria for particulate matter. Further details on the *Voluntary Land Acquisition and Mitigation Policy* are provided in Section 6.3.1.

Voluntary mitigation and voluntary acquisition rights apply when a development contributes to exceedances of the criteria set out in Table 10.3. The criteria are the same with the exception of the number of allowable days above the 24 hour impact assessment criteria for PM_{10}, which is zero for mitigation and five for acquisition. The criteria are the same as they are designed for the protection of human health and essentially provide the land owner with the option for either mitigation or acquisition.

Table 10.3 Particulate matter mitigation and acquisition criteria

Pollutant	Averaging period	Mitigation criterion		Impact type
PM_{10}	24 hour	50 µg/m^3 *		Human health
	Annual	30 µg/m^3 **		Human health
TSP	Annual	90 µg/m^3 **		Amenity
Deposited dust	Annual	2 g/m^2/month *	4 g/m^2/month **	Amenity

Source: *VLAMP November 2014.*

Notes: *1. Incremental increase due to development alone, with zero allowable exceedances over the life of the development.*

2. Cumulative impact due to the development plus background from other sources.

10.3.2 Emissions inventory

A comprehensive emissions inventory was compiled for the Balranald Project covering a range of air pollutants including various particle size fractions, a range of air toxins including metals, metalloids, RCS, speciated volatile organic gases and several common gaseous emissions associated with combustion. Based on the extent of the emissions, the source characteristics and the proximity of sources to assessment locations, particulate matter, trace metal/metalloid and RCS emissions were prioritised for modelling and quantitative air quality impact assessment.

The inventory was developed based on the proposed mine plan and equipment fleet. Emissions from each source were quantified primarily using the USEPA AP-42 predictive emission factor equations (USEPA 2010).

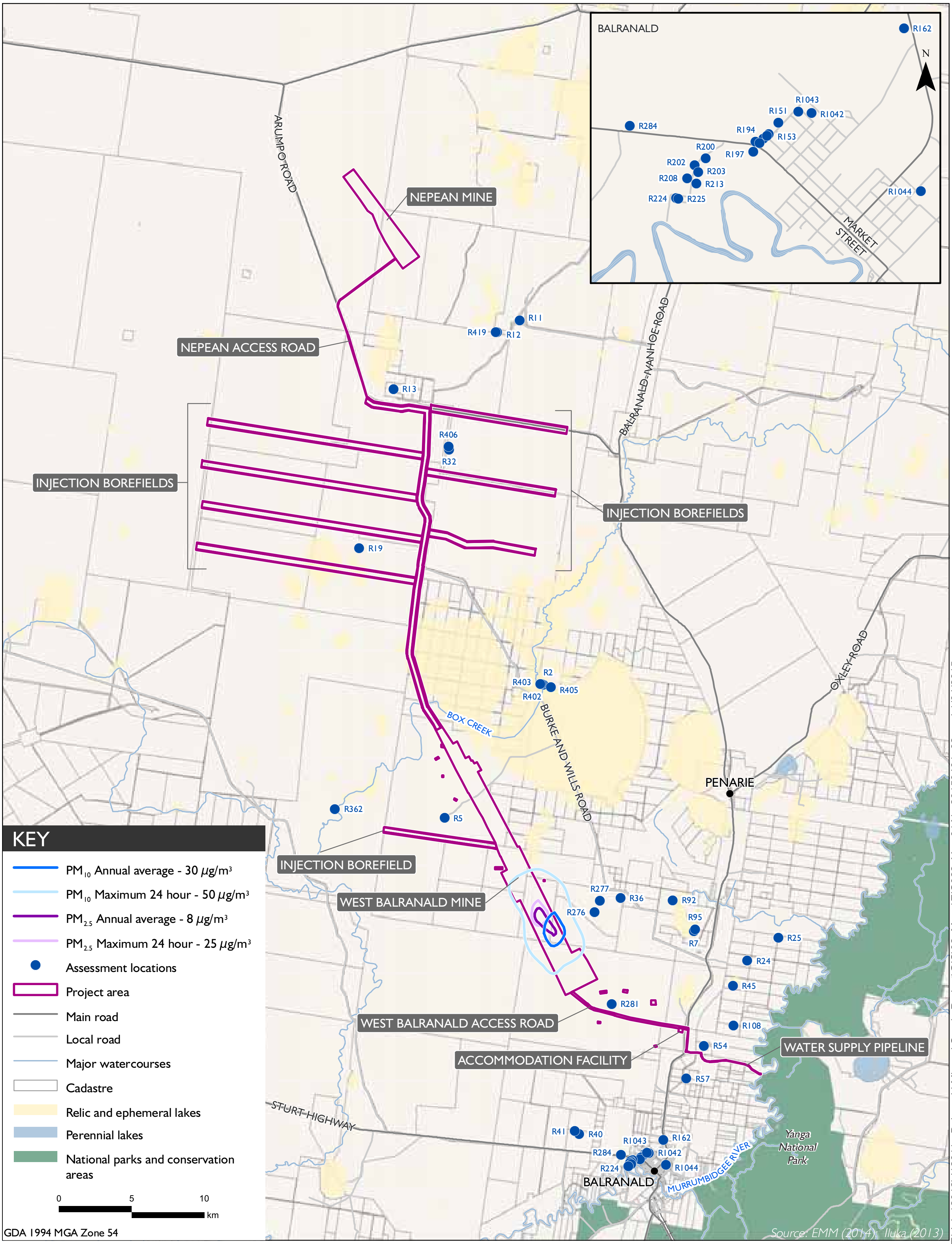
Emissions inventories have been developed for three operational scenarios, selected to assess the air quality impacts of worst-case operations, for example where material movement is highest, where extraction or wind erosion areas are largest, or where operations are located closest to receivers, as follows:

- Year 1 - mining operations at the West Balranald mine are located close to three assessment locations to the east including R276, R277 and R36;
- Year 4 - mining operations at the West Balranald mine to the closest assessment location to the west (R5); and
- Year 8 - mining operations at the Nepean mine at highest material movement with concurrent mining operations at the West Balranald mine.

Although Year 5 has the greatest amount of material moved, Year 4 has more out of pit material movement and was therefore selected as a worst case emission scenario.

10.3.3 Assessment locations

The air quality assessment used a modelling domain of 80 km wide and 130 km long centred to cover the West Balranald and Nepean mines. Within this domain, 345 assessment locations were identified based on aerial photography interpretation (see Appendix A of Appendix E for full list of assessment locations). Assessment locations largely included homesteads, dwellings and other built structures (eg sheds and other outbuildings). The assessment locations can be seen in Figures 10.1, 10.2 and 10.3.



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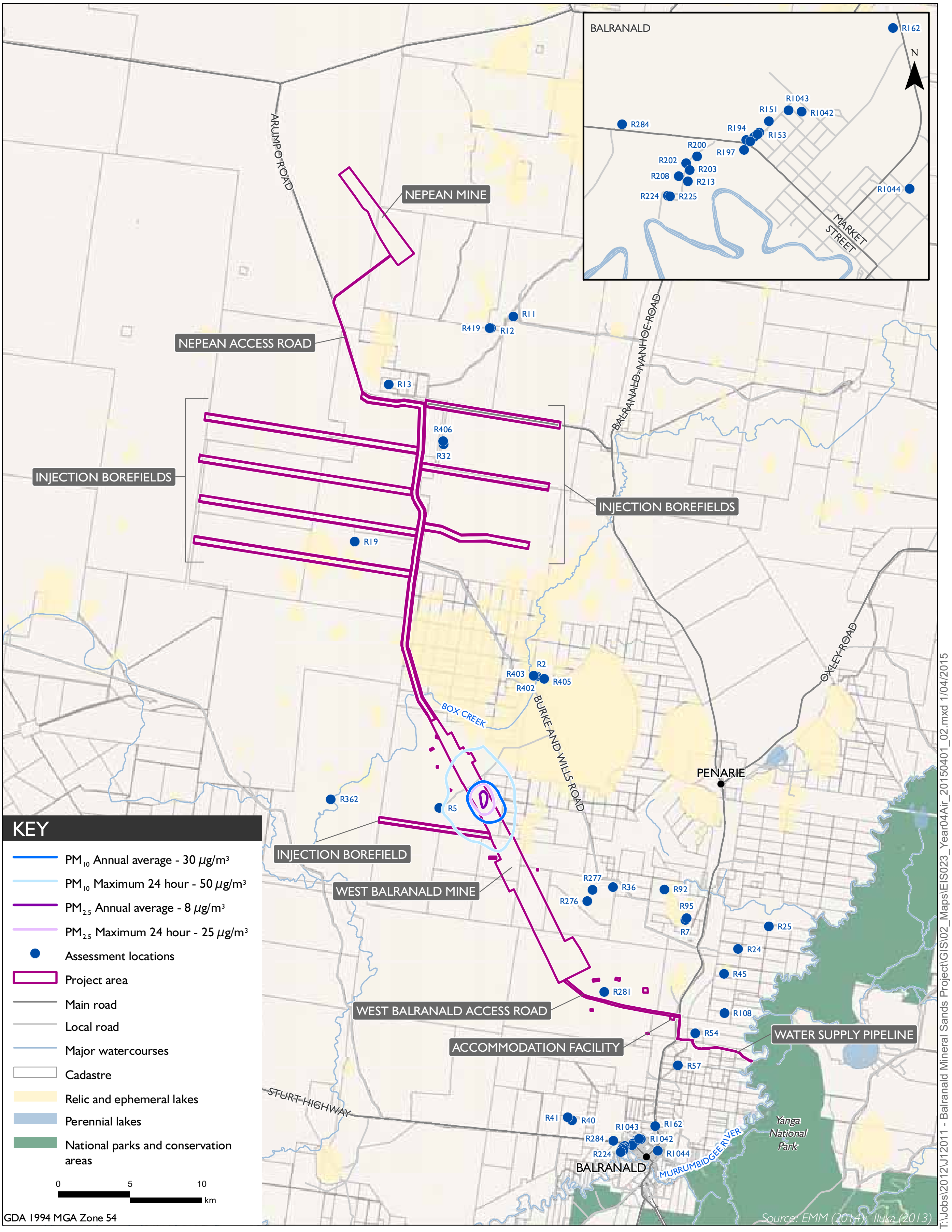
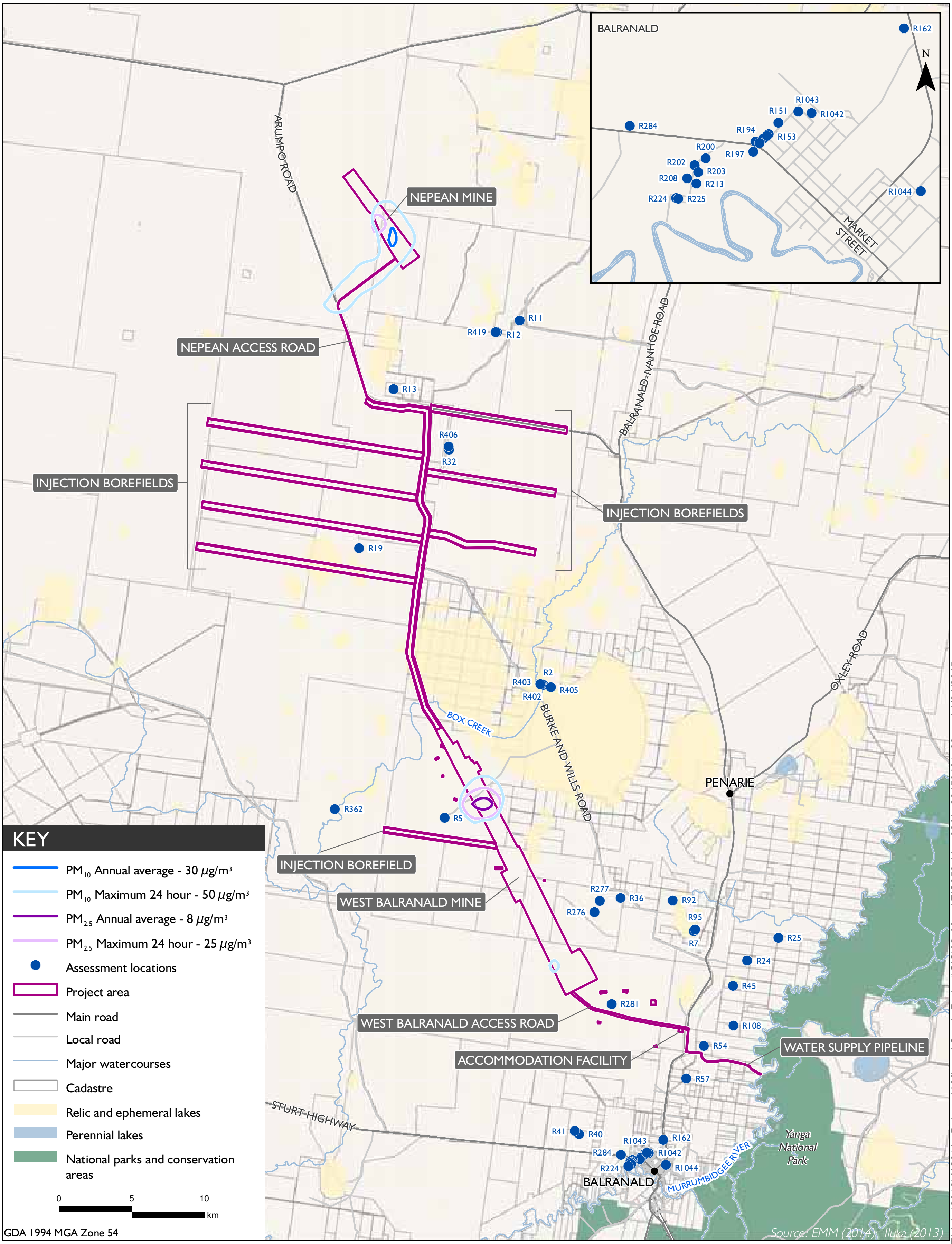
PM_{10} and $PM_{2.5}$ - Incremental 24 hour average and incremental annual average - Year 1

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 10.1



PM_{10} and $PM_{2.5}$ - Incremental 24 hour average and incremental annual average - Year 4

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 10.2



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PM_{10} and $PM_{2.5}$ - Incremental 24 hour average and incremental annual average - Year 8

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Figure 10.3

10.3.4 Air quality modelling

The atmospheric dispersion modelling applied within this assessment was the USEPA regulatory AERMOD model. AERMOD was identified as the most suitable model for application for the Balranald Project due to the source types (predominately surface based, non-buoyant fugitive releases) and the observed low variability of meteorological conditions in the vicinity of the project area, most notably in relation to wind direction. A detailed account of the model selection and modelling methodology is presented in Appendix H of the air quality assessment contained in Appendix E.

The dispersion of pollutants was modelled for an area covering 80 km by 130 km centred over the West Balranald and Nepean mines. Following inter-annual meteorological analysis, the calendar year 2011 was chosen as the meteorological period for the dispersion modelling. Emissions were estimated based on activity data for three operational years (Year 1, 4 and 8). The location of sources, including haul roads, ore and waste loading/unloading activities, dozer operations and wind erosion were selected based on the indicative equipment locations provided by Iluka.

A suite of mitigation and air quality control measures are proposed as part of the Balranald Project. These mitigation measures are presented in Section 10.4, and have been taken into account in the quantification of air quality emissions for the Balranald Project.

Dispersion modelling results were predicted at each of the assessment locations surrounding the project area for the mines operating in isolation (incremental), and taking in to consideration background air quality concentrations (cumulative).

10.3.5 Results

i Operational scenarios

The predicted ground level concentrations at the ten most potentially impacted assessment locations for incremental air pollutant concentrations and dust deposition (PM_{10}, $PM_{2.5}$, TSP and dust deposition) during Year 1, Year 4 and Year 8 operations for are presented in Table 10.4, Table 10.5 and Table 10.6 and Figures 10.1, 10.2 and 10.3.

The modelling results indicate that there are no predicted exceedances of the annual average impact assessment criteria (increment or cumulative) for PM_{10}, $PM_{2.5}$, TSP or dust deposition for any of the modelled operational years at the ten most potentially impacted assessment locations.

There is no continuous PM_{10} data in the vicinity of the Balranald Project to apply a Level 2 cumulative assessment for 24-hour PM_{10}, as recommended by the Approved Methods. Cumulative impacts for 24-hour PM_{10} have therefore been evaluated using a statistical approach which presents the likelihood of the Balranald Project causing additional exceedances of the 24-hour average assessment criterion of 50 µg/m^3.

Table 10.4 Year 1 operations – model predictions for the 10 most potentially impacted assessment locations

	PM_{10} concentration (µg/m³)			$PM_{2.5}$ concentration (µg/m³)			TSP concentration (µg/m³)		Dust deposition (g/m³/month)	
	24 hour max	**Annual average**		**24 hour max**	**Annual average**		**Annual average**		**Annual average**	
Criteria	**50**	**30**		**25**	**8**		**90**		**2**	**4**
Assessment location	**Incremental**	**Incremental**	**Cumulative**	**Incremental**	**Incremental**	**Cumulative**	**Incremental**	**Cumulative**	**Incremental**	**Cumulative**
R276	24.7	3.8	21.8	4.6	0.8	7.3	7	50.8	0.18	1.32
R277	19.9	2.9	20.9	3.9	0.6	7.1	5.3	49.1	0.12	1.26
R281	13.5	1	19	2.4	0.2	6.7	1.6	45.4	0.03	1.17
R36	12.8	1.8	19.8	2.4	0.4	6.9	3.1	46.9	0.06	1.2
R403	11.1	0.7	18.7	1.9	0.1	6.6	1	44.8	0.01	1.15
R402	10.8	0.7	18.7	1.8	0.1	6.6	1	44.8	0.01	1.15
R5	10.5	0.8	18.8	2.3	0.2	6.7	1.3	45.1	0.02	1.16
R2	10.4	0.7	18.7	1.8	0.1	6.6	1	44.8	0.01	1.15
R92	9.2	0.8	18.8	1.8	0.2	6.7	1.4	45.2	0.03	1.17
R405	8.6	0.7	18.7	1.5	0.1	6.6	1.1	44.9	0.01	1.15

Notes: Additional cumulative assessment for short term (24-hour average) PM_{10} and $PM_{2.5}$ can be found in Appendix E.

Table 10.5 Year 4 operations – model predictions for the 10 most potentially impacted assessment locations

	PM10 concentration (µg/m^3)			$PM_{2.5}$ concentration (µg/m^3)			TSP concentration (µg/m^3)		Dust deposition (g/m^3/month)	
	24 hour max	Annual average		24 hour max	Annual average		Annual average		Annual average	
Criteria	50	30		25	8		90		2	4
Assessment location	Incremental	Incremental	Cumulative	Incremental	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative
R5	43.9	4.4	23.3	5.9	1.2	7.7	7.1	50.9	0.08	1.22
R403	9.6	1.3	20.2	1.6	0.3	6.8	2	45.8	0.03	1.17
R402	9.6	1.3	20.2	1.6	0.3	6.8	2	45.8	0.03	1.17
R2	9.5	1.2	20.1	1.6	0.3	6.8	2	45.8	0.03	1.17
R405	9.3	1.2	20.1	1.5	0.3	6.8	1.9	45.7	0.02	1.16
R277	8.9	0.8	19.7	1.3	0.2	6.7	1.3	45.1	0.02	1.16
R276	8.8	0.8	19.7	1.3	0.2	6.7	1.3	45.1	0.02	1.16
R362	8.3	0.6	19.5	1.3	0.2	6.7	1	44.8	0.01	1.15
R36	6.3	0.7	19.6	0.9	0.2	6.7	1.1	44.9	0.01	1.15
R366	4.6	0.4	19.3	0.8	0.1	6.6	0.7	44.5	0.01	1.15

Notes: Additional cumulative assessment for short term (24-hour average) PM_{10} and $PM_{2.5}$ can be found in Appendix E.

Table 10.6 Year 8 operations – model predictions for the 10 most potentially impacted assessment locations

	PM10 concentration (µg/m^3)			$PM_{2.5}$ concentration (µg/m^3)			TSP concentration (µg/m^3)		Dust deposition (g/m^3/month)	
	24 hour max	Annual average		24 hour max	Annual average		Annual average		Annual average	
Criteria	**50**	**30**		**25**	**8**		**90**		**2**	**4**
Assessment location	**Incremental**	**Incremental**	**Cumulative**	**Incremental**	**Incremental**	**Cumulative**	**Incremental**	**Cumulative**	**Incremental**	**Cumulative**
R281	20.8	7	25	1.8	0.6	7.1	8.5	52.3	0.2	1.3
R5	16.2	1.8	19.8	6.5	0.6	7.1	2.8	46.6	0.03	1.17
R13	5.1	1.9	19.9	0.8	0.3	6.8	3.9	47.7	0.07	1.21
R54	4.6	0.8	18.8	0.6	0.1	6.6	1.3	45.1	0.02	1.16
R405	4.3	0.6	18.6	1.3	0.1	6.6	0.9	44.7	0.01	1.15
R419	3.8	0.7	18.7	0.8	0.1	6.6	0.8	44.6	0	1.14
R12	3.8	0.7	18.7	0.8	0.1	6.6	0.8	44.6	0	1.14
R2	3.7	0.6	18.6	1.1	0.1	6.6	1	44.8	0.01	1.15
R402	3.7	0.6	18.6	1.1	0.1	6.6	1	44.8	0.01	1.15
R403	3.6	0.6	18.6	1.1	0.1	6.6	1	44.8	0.01	1.15

Notes: Additional cumulative assessment for short term (24-hour average) PM_{10} and $PM_{2.5}$ can be found in Appendix E.

The analysis shows that the risk of additional exceedances of the 24-hour PM_{10} impact assessment criteria is low, summarised as follows:

- During Year 1 operations, the highest risk occurs at R276 where the probability of additional days over 50 µg/m³ is approximately 1%. At all other assessment locations, the probability is less than 0.2%.

- During Year 4 operations, the highest risk occurs at R5 where the probably of additional days over 50 µg/m³ is approximately 2.3%. At all other assessment locations, the probability is less than 0.4%.

- During Year 8 operations, the highest risk occurs at R281 where the probability of additional days over 50 µg/m³ is approximately 1.8%. At all other assessment locations, the probability is less than 0.5%.

A similar statistical analysis was used for $PM_{2.5}$ to determine the likelihood of the Balranald Project causing additional exceedances of the 24-hour advisory reporting standard of 25 µg/m³. The analysis resulted in a risk of exceedances of the criterion of less than 0.1% for all modelled years.

ii Other air pollutants

Predicted trace metal/metalloid and RCS concentrations were predicted to be well below the relevant assessment criteria across all assessment locations and averaging periods for all three years modelled of the Balranald Project (refer to Appendix E).

iii Land acquisition and mitigation

Based on the results of the air quality assessment, no mitigation to or acquisition of assessment locations is required as a result of the Balranald Project.

10.4 Management and mitigation

An air quality management plan would be prepared for the Balranald Project to detail management measures to minimise the emission of particulates and gaseous pollutants. The key management measures (which have been assumed to be operating as part of the dispersion modelling) are described in the following sections.

10.4.1 Construction

Construction activities would have a total duration of up to about 2.5 years, with individual activities staged in shorter periods over this time. Management and mitigation measures that would be implemented during the construction stages of the Balranald Project to minimise dust generation are as follows:

- minimise the extent of exposed areas as far as practical throughout the construction phase;

- stabilise exposed areas (eg vegetation, chemical stabilisation) as soon as practical;

- all unsealed roads and other trafficked areas would be watered regularly to minimise dust emissions;

- consider the application of water extenders to improve the control effectiveness of watering;

- consider the prevailing wind direction and speed in short term planning of construction operations, particularly when activities are close to assessment locations;
- consider modifying construction activities under adverse meteorological conditions (dry, windy conditions) when assessment locations are located downwind of the construction activities;
- minimise double handling of material; and
- locate stockpiles in sheltered areas where possible.

10.4.2 Operation

Mitigation measures that would be implemented during the operational phase of the Balranald Project to minimise dust generation are as follows:

- minimise the drop height of excavators loading material to trucks;
- minimise the drop height of front end loaders loading ROM ore to dump hoppers;
- all unsealed roads and other trafficked areas would be watered regularly to minimise dust emissions;
- consider application of chemical suppression where practical to minimise dust generation;
- emissions from the ISP would flow through a baghouse filter before being emitted;
- considering modifying operations during periods of dry, windy conditions where watering is not providing required mitigation;
- maximise direct in-pit placement of overburden, minimising the potential for wind erosion;
- minimise double handling of material, wherever practicable;
- progressive rehabilitation of disturbed areas as soon as practical; and
- temporary stabilisation of long-term topsoil stockpiles.

Due to predicted ground level concentrations being well below impact assessment criteria, monitoring during operations at the Balranald Project would be limited to a network of dust deposition gauges (DDGs). The DDGs would be used to monitor the change in local dust levels due to the operation of the Balranald Project. The number and location of the dust deposition gauges would be outlined in the air quality management plan and would be would be consistent with similar operations in the region.

Iluka also proposes to operate a meteorological monitoring station on-site. The purpose of the meteorological station is to:

- provide the site with daily, monthly and yearly weather summaries;
- provide information on ongoing trends, for example monthly rainfall statistics;
- assist the site in responding to dust complaints by helping to identify the source of dust (based on wind measurements);

- identify excessive temperatures to inform stop work requirements under OHS requirements;
- provide weather observations to support noise monitoring (as required);
- enable calculations of stability class for noise assessment (as required); and
- provide site specific weather observations for future air quality assessment (as required).

10.5 Conclusion

The air quality assessment examined predicted concentrations of airborne particulates, toxic pollutants, and dust deposition. The emissions were quantified and modelled for Year 1, 4 and 8 to assess the potential for air quality impacts on the surrounding environment.

Across all assessed mine years, the modelling results indicate that there are no predicted exceedances of the annual average impact assessment criteria (increment or cumulative) for PM_{10}, $PM_{2.5}$, TSP or dust deposition.

There are no continuous PM_{10} data in the vicinity of the Balranald Project to apply a Level 2 cumulative assessment, as recommended by the Approved Methods. Therefore, a statistical approach was used to evaluate 24-hour PM_{10} and 24-hour $PM_{2.5}$ exceeding the relevant criteria. The results found that the highest risk of 24-hour PM_{10} exceeding the criteria was at assessment location R5 with a 2.3% chance during Year 4 operations. The analysis for 24-hour $PM_{2.5}$ exceeding the criteria was less than 0.1% for all years.

Trace metal/metalloid and RCS concentrations due to the Balranald Project were predicted to comply with relevant impact assessment criteria across all years assessed.

11 Greenhouse Gas

11.1 Introduction

The SEARs require an assessment of greenhouse gas (GHG) emissions from the Balranald Project. The SEARs require this EIS to include:

> an assessment of the likely greenhouse gas impacts of the development, dealing with the EPA's requirements.

A GHG assessment was undertaken by Environ for the Balranald Project and is provided in Appendix E. The assessment was undertaken in accordance with the following regulations, methods and guidance documents as specified in the SEARs:

- Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGERS Act);
- *National Greenhouse Accounts Factors - Australian National Greenhouse Accounts* (NGAF) (DoE *2014a);*
- *Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia - National Greenhouse and Energy Reporting (NGER) (Measurement) Determination 2008* (DoE 2014b);
- *Guidelines for Energy Savings Action Plans (GESAPs), issued by NSW-Department of Energy, Utilities and Sustainability* (NSW-DEUS);
- *Second International Maritime Organisation (IMO) – Greenhouse Gas Study 2009* (IMO 2009); and
- Australian National Greenhouse Gas Inventory – Kyoto Protocol Accounting Framework.

Organisational and operational boundaries for the Balranald Project and the calculations of Scope 1, 2 and 3 (as defined below) GHG emissions from the Balranald Project are described below.

This chapter is a summary of the assessment in Appendix E.

11.2 Existing environment

GHGs are naturally present in the atmosphere and contribute to its warming by absorbing long-wave radiation reflected from the earth's surface. Human activities, such as burning fossil fuels and deforestation, have increased atmospheric GHG concentrations and are associated with warming of the earth's surface (Intergovernmental Panel on Climate Change (IPCC) 2007). These changes in GHGs are linked to climate change. The most important GHGs originating from human activity are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (IPCC 2007).

11.3 Impact assessment

11.3.1 Methodology

i Organisational boundary

The organisational boundary for the assessment was defined for the Balranald Project using the operational control approach, as defined in the NGERS Act. The NGERS Act defines operational control as:

> A corporate group member has operational control of a facility if it has the authority to introduce and implement any or all of the operating, health and safety and environmental policies for the facility. Only one corporation or group member can have operational control of a facility at a time.

In the case of the Balranald Project, Iluka would account for all of the GHG emissions over which it has operational control. Iluka would not account for emissions in which it owns an interest but does not have operational control.

The operation of the Balranald Project would rely on a number of contractors. Iluka would account for emissions associated with its major contractors under its own Scope 1 and 2 emissions (as defined below), since it has authority to implement OHS and environmental policies in relation to the activity of these contractors within the project area.

ii Operational boundary

Direct GHG emissions are produced from sources within the operational boundary of an organisation and as a result of that organisation's activities. These are termed Scope 1 emissions.

Indirect GHG emissions are generated in the wider economy as a consequence of an organisation's activities and are termed Scope 2 and 3 emissions.

iii Emissions sources

Direct (Scope 1) and indirect (Scope 2 and 3) emissions have been defined based on the Balranald Project description (Chapter 4).

Scope 1 emissions include the combustion of diesel and LPG.

Scope 2 emissions include the generation of purchased electricity that will be used by mine infrastructure (eg pumps, workshops and maintenance facilities and offices).

Scope 3 emissions include:

- upstream emissions generated from the supply of raw materials;
- downstream emissions generated from off-site transportation and distribution of final product; and
- commuting of work personnel (business and personal).

The annual emissions of CO_2, CH_4, and N_2O were used to calculate total GHG emissions as carbon dioxide equivalents (CO_2-e).

11.3.2 Results

Table 11.1 shows the calculated annual GHG emissions from Scope 1, 2 and 3 for years 1 to 8.

Table 11.1 Calculated annual GHG emissions – Years 1 to Year 8

Mine year	Annual GHG emissions (t CO_2–e/yr) by scope			Total annual GHG emissions (t CO2 – e/yr)
	Scope 1	Scope 2	Scope 3	
Year 1	61,782	66,220	196,498	324,500
Year 2	66,508	66,220	428,465	561,193
Year 3	78,809	66,220	528,092	673,121
Year 4	83,601	66,220	433,395	583,216
Year 5	85,052	66,220	475,440	626,713
Year 6	81,113	66,220	418,625	565,958
Year 7	86,813	66,220	437,344	586,521
Year 8	84,724	66,220	474,444	625,388

i Direct (Scope 1) emissions

Direct emissions generated by the Balranald Project represent between 0.04% and 0.055% of total annual NSW emissions, 0.011% to 0.015% of Australian emissions and between 0.00013% and 0.00016% of global emissions.

ii Indirect (Scope 2 and 3) emissions

Indirect emissions generated by the Balranald Project represent between 0.063% and 0.081% of annual NSW emissions, 0.018% to 0.023% of Australian emissions and between 0.0005% and 0.0012% of global emissions.

11.4 Management and mitigation

An air quality management plan would be developed to detail management measures to minimise GHG emissions from the Balranald Project. Mitigation measures that would be implemented to reduce Scope 1 emissions from the Balranald Project include:

- use mining equipment which is regularly maintained and serviced to maximise efficiency;
- use of fuel efficient plant and equipment;
- proper maintenance of the plant and equipment for maximising efficiency;
- use of lower emission fuels (biodiesel, natural gas) where practical;
- reduce fuel consumption by minimising the vehicle kilometres travelled on-site where possible; and
- plan operations well in advance in order to minimise resource non-utilisation and wastage.

Scope 2 and Scope 3 are indirect emissions generated off-site, and as such Iluka has limited control to reduce these emissions. However, some measures may be feasible and these include:

- source materials locally where feasible to minimise emissions generated from upstream activities;
- adopt the use of energy efficient lighting technologies and hot water and air conditioning systems wherever practical;
- use of alternative energy sources where practical such as solar power and green power;
- progressively review and implement energy efficiency measures throughout the life of the Balranald Project;
- undertaking awareness and training programs on energy efficiency measures for site personnel;
- investigating alternative haulage systems (eg trucks with larger payload capacity) for reducing the number of trips taken for material/product transportation; thereby reducing the vehicle kilometres travelled; and
- conduct periodic audits and reviews on the amounts of materials used, amount of mine waste and non-mine waste generated and disposed.

11.5 Conclusion

The GHG assessment estimated GHG emissions from the Balranald Project to determine its contributions to NSW and Australia GHG emissions based on available information and relevant emission factors.

Indirect emissions (Scope 2 and Scope 3) are the major contributors of the Project's GHG emissions. Of the indirect emissions, downstream product transport to the international market on average accounts for 80% of indirect emissions.

Direct emissions generated by the Balranald Project represent between 0.04% and 0.055% of total annual NSW emissions, 0.011% to 0.015% of Australian emissions and between 0.00013% and 0.00017% of global emissions.

Indirect emissions generated by the Balranald Project represent between 0.063% and 0.081% of annual NSW emissions, 0.018% to 0.023% of Australian emissions and between 0.0005% and 0.0012% of global emissions.

The annual GHG emissions for the Balranald Project from Year 1 to Year 8 were estimated to be between 0.3 Mt and 0.6 Mt of CO_2-e/yr.

12 Ecology

12.1 Introduction

The SEARs require an assessment of biodiversity impacts from the Balranald Project. The SEARs require this EIS to include an assessment of biodiversity including:

> an assessment of the likely biodiversity impacts of the development, having regard to the principles and strategies in the draft NSW Biodiversity Offsets Policy for Major Projects and the requirements of OEH;
>
> measures taken to avoid, reduce or mitigate impacts on biodiversity;
>
> accurate estimates of proposed vegetation clearing; and
>
> a comprehensive offset strategy to ensure the development maintains or improves the terrestrial and aquatic biodiversity values of the region in the medium to long term.

A biodiversity assessment was undertaken by Niche Environment and Heritage (Niche) for the Balranald Project and is provided in Appendix F. The assessment was undertaken in accordance with the following regulations, methods and guidance documents as specified in the SEARs:

- *Draft NSW Biodiversity Offset Policy for Major Projects* (OEH 2014);
- *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECCW 2009);
- *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft* (DECC 2004);
- *Threatened Species Assessment Guidelines: the Assessment of Significance* (DECC 2007);
- *Guidelines for Threatened Species Assessment* (DoP 2005);
- *BioBanking Assessment Methodology* (BBAM) (OEH 2104);
- *Framework for Biodiversity Assessment* (FBA) (OEH 2014);
- *Environmental Offsets Policy* (Commonwealth DoE 2012);
- *NSW State Groundwater Dependent Ecosystem Policy* (DLWC 2002);
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NOW 2012);
- *Policy & Guidelines - Fish Friendly Waterway Crossings* (NSW Fisheries 2003);
- *Policy & Guidelines - Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 2013); and
- *State Environmental Planning Policy No. 44 – Koala Habitat Protection*.

This chapter is a summary of the assessment in Appendix F.

12.2 Existing environment

12.2.1 Methods

i Database and literature review

To characterise ecological features of the project area a detailed review of relevant literature and vegetation mapping was undertaken as well as searches of relevant databases. This background information was used to design the ecological field surveys that were commensurate with the species and the extent of potentially suitable habitat identified within and adjoining the project area.

Threatened species databases and previous documents relevant to the Balranald Project reviewed to identify threatened species, populations and communities that may occur in the project area included:

- NSW Atlas of Wildlife Database for six 1:100 000 map sheets: Weimby (7528), Bidura (7529), Turlee (7530), Balranald (7628), Paika (7629), Hatfield (7630) (October 2014);
- Threatened Species Profile Search from the OEH website for the Lower Murray Darling CMA and Murrumbidgee catchment management areas (CMAs) (November 2014);
- national rare or threatened Australian plants (ROTAP) database (Briggs and Leigh 1996); and
- Protected Matters Search of a 50 km radius around the project area.

ii Field survey

Field survey work was completed over four years by Ecotone Ecological Consultants (Ecotone) and Niche within and surrounding the project area. This included survey of:

- the Balranald and Nepean mines and access roads by Ecotone 2011 to 2013; and
- additional ancillary infrastructure, including injection borefields and water supply pipeline by Niche 2013 to 2014.

Given the project areas size and accessibility the survey methods used aimed to provide representative and stratified sampling of:

- vegetation and fauna habitat; and
- targeted threatened species.

Where cryptic species were not identified but considered likely to occur and given the scale of the project, these were assumed to occur where suitable habitat was available.

Flora surveys were completed using the methods prescribed in the BBAM (OEH 2014) and FBA (OEH 2014). A total of 125 quadrats, or plots, were completed within the project area and an additional 61 in surrounding areas (greater than 300 m from the project boundary). The number of quadrats completed exceeded the recommendations within OEH's *Threatened Biodiversity Survey and Assessment – Guidelines for Developments and Activities* (DEC 2004), except for vegetation type 11 Flat Open Claypan/Derived Sparse Shrubland. No quadrats were completed given the extremely sparse nature and highly disturbed element within this vegetation type, and benchmark values were used in the offset calculations.

Driving transects were completed throughout all vehicle-accessible parts of the project area, with walking meanders supplementing these where vehicle access was not possible. Transects were used to record vegetation boundaries, the general condition of vegetation in different parts of the project area and any opportunistic flora species not detected in the quadrats. The walking meanders were also used to survey for threatened flora species across the project area.

Flora quadrat locations can be seen in Figure 12.1.

Fauna surveys were completed across the project area and surrounds. Primary fauna survey sites were established in 2011 by Ecotone, mainly within the mine disturbance areas to sample all broad fauna habitats available. The following survey methods were conducted at each primary survey site:

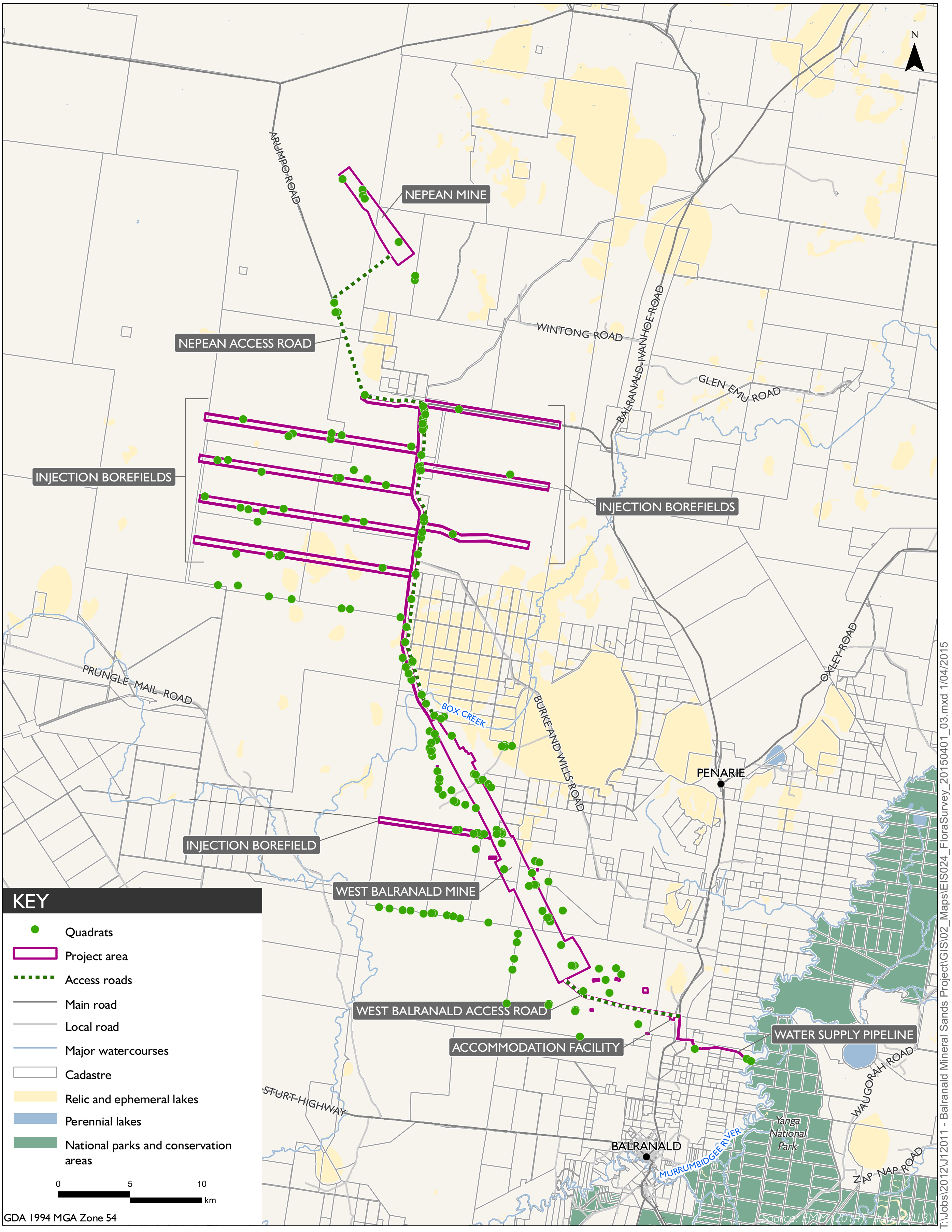
- habitat assessment;
- pitfall trapping, reptile funnel traps and Elliott traps;
- micro-bat survey;
- diurnal reptile census;
- nocturnal survey for mammals, reptiles and frogs;
- remote cameras;
- call playback; and
- sand pads targeting introduced species (Nepean mine only).

Additional fauna surveys were undertaken by Ecotone in the project area in 2012 and 2013 including:

- habitat assessment;
- Malleefowl mound search transects;
- nocturnal and diurnal reptile searches (January 2013 only);
- nocturnal and diurnal call playback specifically targeting the Bush Stone Curlew, Redthroat, Rufous Fieldwren, Shy Heathwren, Striated Grasswren and Southern Scrub-Robin (January 2013 only); and
- driven spotlight transects targeting the Plains Wanderer and nocturnal reptiles (2011 and 2013).

Additional surveys to cover the injection borefields, Murrumbidgee River locality and water supply pipeline area, and West Balranald and Nepean mine areas were sampled by Niche between late 2013 and 2014 including:

- bat and bird surveys;
- full flora and fauna survey (2013 and 2014);
- targeted Regent Parrot survey; and
- survey for Malleefowl.



Flora quadrat locations

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Figure 12.1

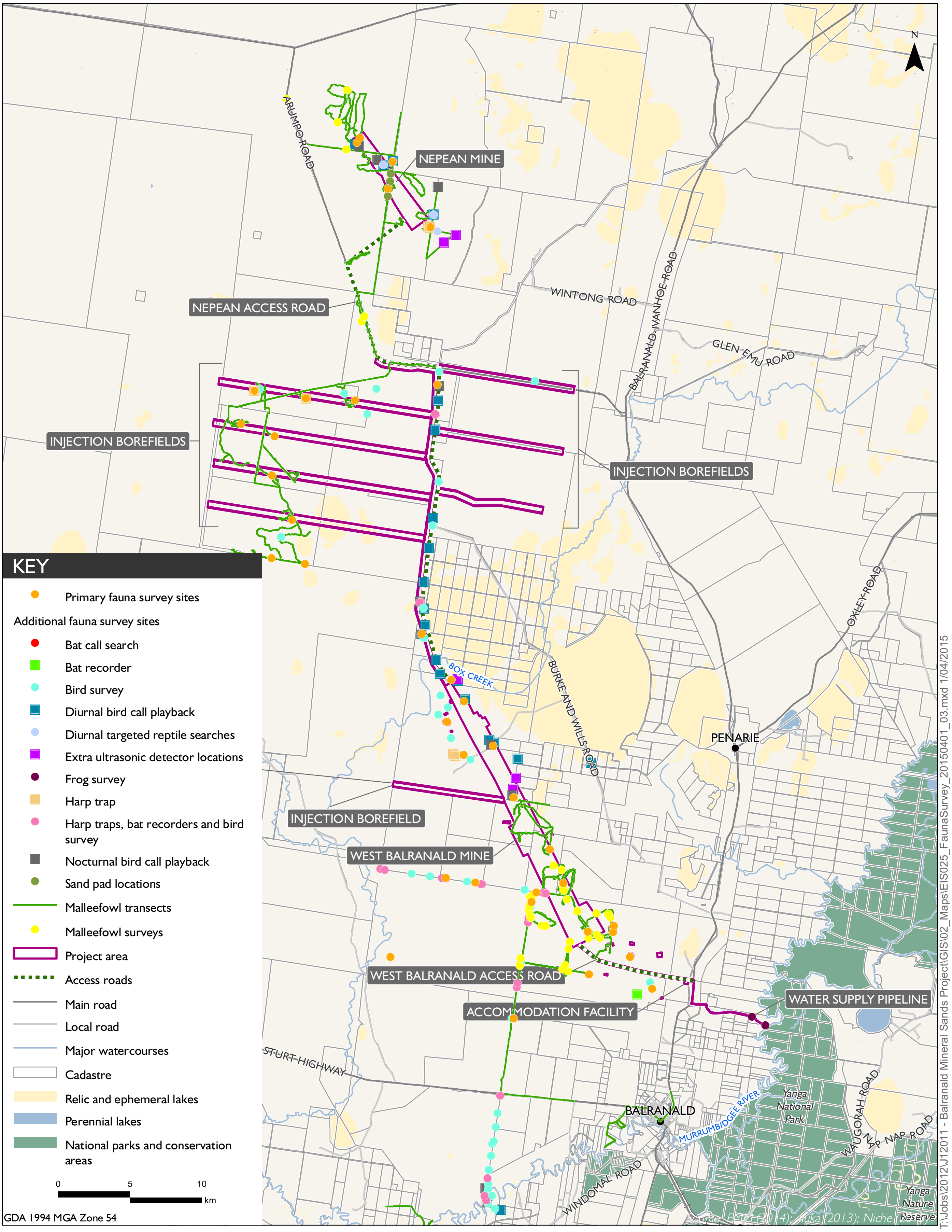
During all surveys, opportunistic observations of fauna or flora habitat and species were recorded.

All fauna survey was completed in accordance with OEH's *Threatened Biodiversity Survey and assessment – Guidelines for Developments and Activities* (DEC 2004) and *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna – Amphibians* (DECCW 2009). The total survey effort for each method is detailed in Table 12.1.

Fauna survey locations can be seen in Figure 12.2.

Table 12.1 Summary of fauna survey effort

Survey method	Project area (within < 1km)					Outside project area	Total survey effort
	Nepean mine	West Balranald mine	Nepean access road	Borehole injection areas	Water supply pipeline		
Bat call detectors (handheld - hours)	5	8	0	0	0	0	**13**
Bat call detectors (stationary - nights)	12	20	14	10	0	54	**110**
Camera traps (nights)	63	94	38	154	0	393	**742**
Diurnal bird survey (20 min surveys)	6	7	22	20	2	95	**152**
Diurnal call playback (15 min surveys)	4	6	0	16	0	9	**35**
Diurnal reptile searches (hours)	8	9	7	9	0	14.5	**47.5**
Elliot traps (nights)	214	304	100	1040	0	1,110	**2,768**
Frog census and active search (hours)	1	2	0	0	3	3	**9**
Harp traps (nights)	10	16	10	2	0	40	**78**
Malleefowl mound checks	0	4	0	0	0	5	**9**
Malleefowl transects (hours)	38	23	7	0	0	29	**97**
Nest boxes (nights)	0	0	240	32	0	1,952	**2,224**
Nocturnal call playback (15 min surveys)	2	8	3	1	0	1	**15**
Nocturnal spotlight (driven/walked – hours)	9	12	1	10	0	22.5	**54.5**
Pitfall traps (nights)	166	196	20	98	0	126	**606**
Predator scats	22	8	0	0	0	0	**30**
Reptile funnels (nights)	214	304	0	0	0	0	**518**
Sand plots (nights)	9		0	0	0	0	**9**



Fauna survey locations

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Figure 12.2

iii Results

iv Database and literature review

The project area occurs in the Murray Darling Depression and Riverina Bioregion and the South Far Western Plains botanical subregion, and occurs over two CMAs, the Lower Murray Darling CMA and Murrumbidgee CMA.

The project area traverses the Lachlan Lakes, Swamps and Lunettes, Lachlan Depression Plains, Mallee Cliffs Sandplains, and Lachlan Channels and Floodplains Mitchell Landscapes. The northern third of the west Balranald mine consists of flat alluvial and lacustrine deposits of gravel, sand, silt and clay. The southern two-thirds consists of Aeolian flats to gently undulating plains and dunes of red and red-brown clayey sands and loams. The Nepean mine consists of tertiary marine and non-marine sediments overlain with Quaternary aeolian fluvial and lacustrine deposits of sand, silt and clay (Soil Conservation Service of NSW 1990).

The Murrumbidgee River occurs to the east and south of the project area. The West Balranald mining area is part of the catchment for Paika Creek (central) and Box Creek (northern part). Dry lake beds (Muckee and Tin Tin) occur in the northern half and are currently being cropped. The Nepean mining area is part of the catchment for Box Creek and dry lake beds occur to the east and south.

The West Balranald mine passes through an area of SMCA which is fenced and set aside as an offset for clearing mallee remnants for agriculture. The Nepean mining area occurs within a large area of Linear Dune Mallee with approximately 60% of the area being within the Wampo SMCA. This conservation area contains known habitat for the listed threatened species.

The searches and literature review identified 34 threatened flora species that are known or could occur in the project area, including:

- two species listed as critically endangered under TSC Act;
- 19 species listed as endangered under the TSC Act and five under the EPBC Act; and
- 12 species listed as vulnerable under the TSC Act and nine under the EPBC Act.

Eight threatened ecological communities (TECs) listed under the TSC Act and three listed under the EPBC Act are known or could occur in the project area.

The searches and literature review also identified 81 threatened fauna species that are known or could occur in the project area, including two amphibians, 58 birds, 12 mammals and nine reptiles comprising:

- two species listed as critically endangered under TSC Act;
- 21 species listed as endangered under the TSC Act and six under the EPBC Act;
- 49 species listed as vulnerable under the TSC Act and 10 under the EPBC Act; and
- nine species listed as migratory under the EPBC Act.

No critical habitat declared under the TSC Act was identified for threatened flora or fauna.

Potential impacts on GDEs were evaluated in the Groundwater Dependant Ecosystems Assessment Report (Appendix J). The methods and results of this analysis is presented in Chapter 14.

v Vegetation

The project area contains three broad areas and types of vegetation.

The northern part of the project area (where the Nepean mine is located) is dominated by Saltbush, Chenopod and Black Box communities, with some woodland. Some dry lakes and claypans also occur. The northern part of the Nepean mine is part of a SMCA. Areas outside the SMCA are used for agricultural purposes, particularly sheep grazing.

The southern area part of the project area is dominated by Mallee communities, consisting of Spinifex Mallee interspersed with Chenopod Mallee and pure Chenopod Mallee closer to the centre of the West Balranald mine. The far southern end of the West Balranald mine area has been mostly cleared for crops with remnant patches or strips of native Mallee vegetation. The West Balranald mine contains mostly agricultural land used for grazing and cropping, with remnant native vegetation consisting of patches of mallee and saltbush plains.

All project areas are grazed by feral goats, which have reduced the shrub and ground layer within the Mallee communities.

The Murrumbidgee River locality and water supply pipeline area contains floodplain communities.

During the field survey, 198 flora species were recorded, including a total of 46 introduced species. Eleven native vegetation types were identified in the project area (shown in Figure 12.3) include:

- Vegetation type 1 Spinifex Dune Mallee Woodland;
- Vegetation type 2 Chenopod Sandplain/Swale Mallee Woodland;
- Vegetation type 3 Black Bluebush Low Open Shrubland;
- Vegetation type 4 Pearl Bluebush Low Open Shrubland;
- Vegetation type 5 Bladder Saltbush Low Open Shrubland;
- Vegetation type 6 Old Man Saltbush Shrubland;
- Vegetation type 7 Belah – Pearl Bluebush Woodland;
- Vegetation type 8 Belah – Chenopod Woodland;
- Vegetation type 9 Black Box – Chenopod Open Woodland;
- Vegetation type 10 River Red Gum Woodland; and
- Vegetation type 11 Flat Open Claypan/Derived Sparse Shrubland/Grassland.

An additional vegetation community was identified; Vegetation type 12 Cultivated Grain Crops/Cleared Weedy Fallow/Developed. This community is highly modified and consists of mostly bare soil, cultivated and developed areas.

Vegetation types mapped in the project area (see Table 12.2) are shown in only small areas of vegetation types 9 Black Box – Chenopod Open Woodland and 10 River Red Gum Woodland occur in the disturbance area. Black Box – Chenopod Open Woodland occurs in the central-northern part of the West Balranald mine and outer part of the Murrumbidgee River Floodplain, while River Red Gum Woodland only occurs along the banks and floodplain of the Murrumbidgee River along the proposed water supply pipeline. Both communities are in a modified condition from past and ongoing tree thinning, logging and cattle grazing.

A total of 5,160.5 ha of native vegetation was mapped across the disturbance area, with an additional 186.1 ha of non-native vegetation cover or disturbed areas (Table 12.2). Vegetation type 2 Chenopod Sandplain/Swale Mallee Woodland is the most abundant community in the disturbance area. This community occupies flat plains, gently sloping rises and lower-lying swale areas between the crests of the east-west linear dunes in Nepean mine, northern end of the Nepean access road and southern end of West Balranald mine. Vegetation type 4 Pearl Bluebush Low Open Shrubland also has a high abundance over the project area, though mainly in the northern section of the West Balranald mine adjacent to the large dry lakebeds and claypan areas. Both vegetation types are in fair to good condition despite grazing by stock and feral animals.

Noxious weeds were generally absent across the project area with the exception of disturbed areas where at least four declared noxious species occurred in larger amounts. Declared weeds under the NSW *Noxious Weeds Act* 1993 include Onion Weed *(Asphodelus fistulosus)* African Boxthorn *(Lycium ferocissimum)* Noogoora Burr *(Xanthium occidentale)* Bathurst Burr *(Xanthium spinosum).*

Most of the remnant woodland within the project area is mapped as unburnt since at least 1972.

vi Fauna

Most of the project area is subject to grazing by livestock (sheep or cattle), with the exception of the SMCAs, where livestock grazing is not permitted, but grazing by feral herbivores is common. This has resulted in the general absence or reduced diversity of palatable herb and shrub species. The limited ground cover, understorey cover and floral diversity has led to a lower than expected passerine bird diversity in the project area. The surveys also indicated that foxes, feral cats, rabbits, brown hares, pigs, house mice and goats are common, which negatively impacts on vegetation cover, regeneration and consequently native fauna diversity.

Despite this, an array of fauna species was recorded during the surveys including:

- 171 vertebrate species consisting of two frog, 110 bird, 34 reptile and 25 mammal species were recorded in the proposed West Balranald mine;
- 142 vertebrate species consisting of two frog, 80 bird, 34 reptile and 26 mammal species in the proposed Nepean mine;
- 111 vertebrate species consisting of 64 bird, 23 reptile and 24 mammal species in the injection borefield area;
- 15 species in the proposed water supply pipeline route where only nocturnal frog searches were completed; and
- an additional 101 species were recorded from survey outside of the project area but within the locality.

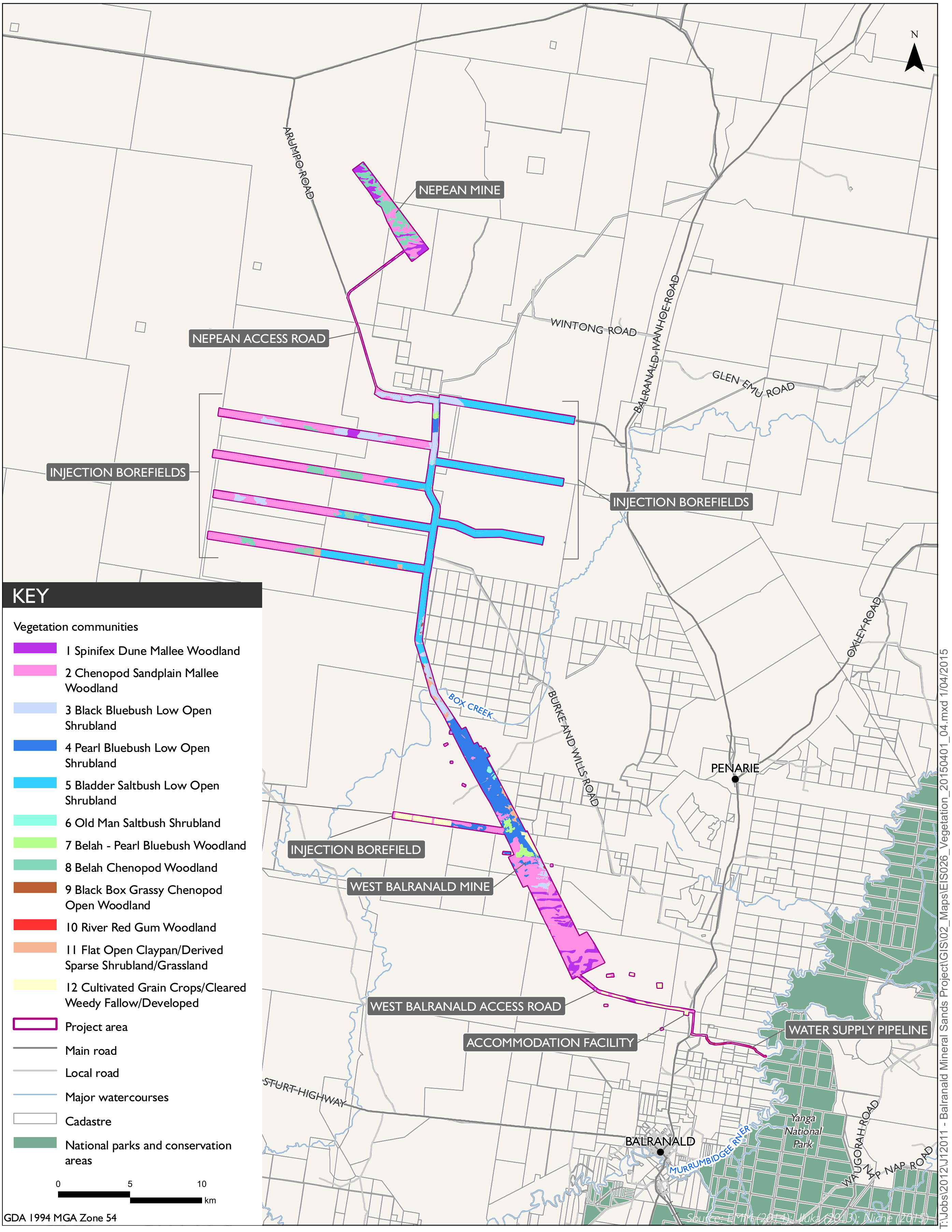
Table 12.2 Vegetation types recorded in the disturbance area

Vegetation formation	Vegetation class	BioMetric vegetation type	Recorded vegetation type	Extent within disturbance area (ha)[1] Nepean mine	Nepean access road	West Balranald mine	West Balranald access road	Borefield	Water supply pipeline	Accommodation facility	Gravel extraction area	Total
Semi-arid woodlands (shrubby sub-formation)	Dune Mallee Woodlands	LM130 - Linear Dune Mallee mainly of the Murray-Darling Basin Bioregion	1. Spinifex Dune Mallee Woodland	187.2	8.6	311.6	7	8.1	0	0	13.9	536.4
	Sand Plain Mallee Woodlands	LM116 - Chenopod sandplain mallee woodland/ shrubland of the arid and semi-arid (warm) zones	2.Chenopod Sandplain/ Swale Mallee Woodland	248.4	28	1,392.20	14.4	366.2	2.3	0	0	2,051.5
	Semi-arid Sand Plain Woodlands	LM107 – Black Oak – Pearl Bluebush open woodland of the sandplains of the semi-arid warm and arid climate zones	7.Belah – Pearl Bluebush Woodland	0	5.3	105.8	0	3.7	0	0	0	114.8
		LM108 – Black Oak – Western Rosewood open woodland on deep sandy loams of Murray-Darling Depression and Riverina Bioregions	8.Belah – Chenopod Woodland	368.3	8	0	0	62.4	0	0	0	438.7
Semi-arid woodlands (grassy sub-formation)	Inland Floodplain Woodlands	LM105 – Black Box open woodland with chenopod understorey mainly on the outer floodplains of the Riverina and Murray-Darling Depression Bioregions	9.Black Box – Chenopod Open Woodland	0	0.2	1.4	0	4.3	1	0	0	6.9
Forested wetlands	Inland Riverine Forests	LM143 – River Red Gum – Lignum very tall open forest or woodland on floodplains of semi-arid (warm) climate zone	10.River Red Gum Woodland	0	0	0	0	0	3.8	0	0	3.8

Table 12.2 Vegetation types recorded in the disturbance area

Vegetation formation	Vegetation class	BioMetric vegetation type	Recorded vegetation type	Extent within disturbance area (ha)[1]								
				Nepean mine	Nepean access road	West Balranald mine	West Balranald access road	Borefield	Water supply pipeline	Accommodation facility	Gravel extraction area	Total
Arid shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LM102 – Black Bluebush low open shrubland of the alluvial plains and sandplains of the arid and semi-arid zones	3.Black Bluebush Low Open Shrubland	0	30	85.6	0	169.3	0	0	0	284.9
		LM138 – Pearl Bluebush low open shrubland of the arid and semi-arid plains	4.Pearl Bluebush Low Open Shrubland	0	8	1,032.5	0	23.9	0	0	7.7	1,072.1
	Riverine Chenopod Shrublands	LM110 – Bladder Saltbush shrubland on alluvial plains in the semi-arid (warm) zone	5.Bladder Saltbush Low Open Shrubland	0	40	0	0	518	0	0	0	558
		LM137 – Old Man Saltbush shrubland mainly of the semi-arid (warm) climate zone (south western NSW)	6.Old Man Saltbush Shrubland	0	0	19.3	0	0.5	0	0	0	19.8
Saline wetlands	Inland Saline Lakes	LM124 - Disturbed annual saltbush forbland on clay plains and inundation zones of the arid and semi-arid climate zones	11.Flat Open Claypan/ Derived Sparse Shrubland/ Grassland	0	1.7	50.9	0	21	0	0	0	73.6
Not classified	12. Cultivated Grain Crops / Cleared Weedy Fallow / Developed			1.2	27.5	59.4	30.5	36.3	3.8	7.1	20.3	186.1
Total				**805.1**	**157.3**	**3,058.7**	**51.9**	**1213.7**	**10.9**	**7.1**	**41.9**	**5,346.6**

Note: 1. Areas in Niche (2015) were calculated to the nearest 0.1 ha.



Mapped vegetation types

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Figure 12.3

Further, several habitat features that are important for both common and threatened fauna species were recorded throughout the project area. This included:

- spinifex clumps: within vegetation type 1 Spinifex Dune Mallee Woodlands, in the southern part of the West Balranald mine and the Nepean mine;
- hollow bearing trees and stags: within vegetation types 2 Chenopod Sandplain/Swale Mallee Woodland, 7 Belah – Pearl Bluebush Woodland and 8 Belah – Chenopod Open Woodland;
- hollow logs and fallen timber: moderately common in vegetation type 1 Spinifex Dune Mallee Woodlands;
- permanent water features: restricted to occasional farm dams in the project area; and
- ephemeral water features: in the eastern end of the proposed water supply pipeline.

Species richness was greater in areas of woodland, and decreased within shrubland habitats particularly those distant from woodland areas. A large number of species, mainly birds, were recorded as opportunistic observations only.

vii Threatened species, populations and communities

No threatened flora species were recorded during the surveys within the project area. However seven species are considered to have a low to moderate likelihood of occurrence within the project area, based on the field surveys and literature review (see Table 12.3). For the purposes of impact assessment, species with a low-moderate likelihood of occurrence and moderate chance of being impacted, were assumed to be present in the disturbance area potentially impacted by the proposal.

Twenty species of threatened fauna were detected during field-survey. All of the species recorded are listed under the TSC Act and three species are also listed under the EPBC Act. An additional six fauna species are considered to have a moderate to high likelihood of occurrence within the project area (Table 12.3).

The locations of recorded threatened species can be seen in Figure 12.4.

Table 12.3 Threatened species recorded or with the potential to be impacted by the project

Common name	TSC Act	EPBC Act	Likelihood of occurrence	Description
Flora				
Mossgiel Daisy (*Brachyscome papillosa*))	V	V	Not recorded Moderate potential	Suitable habitat may occur in vegetation types 5 Bladder Saltbush Low Open Shrubland and 4 Pearl Bluebush Low Open Shrubland.
Winged Peppercress (*Lepidium monoplocoides*)	E	E	Not recorded Moderate potential	Suitable habitat may occur in vegetation types 2 Chenopod Sandplain/Swale Mallee Woodland, 6 Old Man Saltbush Shrubland, 9 Black Box – Chenopod Open Woodland and 5 Bladder Saltbush Low Open Shrubland.
Chariot Wheels (*Maireana cheelii*)	V	V	Not recorded Low-moderate potential	Suitable habitat may occur in vegetation types 5 Bladder Saltbush Low Open Shrubland, 4 Pearl Bluebush Low Open Shrubland, 3 Black Bluebush Low Open Shrubland and 6 Old Man Saltbush Shrubland.

Table 12.3 Threatened species recorded or with the potential to be impacted by the project

Common name	TSC Act	EPBC Act	Likelihood of occurrence	Description
Greenhood Orchid (*Pterostylis cobarensis*)	V	-	Not recorded Low-moderate potential	Suitable habitat may occur in vegetation types 1 Spinifex Dune Mallee Woodland and 2 Chenopod Sandplain/Swale Mallee Woodland. The species is known to be present at a site approximately 20 km north of the project area (AMBS 2013).
Bitter Quandong (*Santalum murrayanum*)	E	-	Not recorded Moderate potential	Suitable habitat may occur in vegetation types 1 Spinifex Dune Mallee Woodland and 2 Chenopod Sandplain/Swale Mallee Woodland. The nearest recent record is at Arumpo Road near the Nepean mine (Ogyris 2007).
Slender Darling Pea (*Swainsona murrayana*)	V	V	Not recorded Moderate potential	Suitable habitat may occur in spinifex mallee communities, particularly with Eucalyptus dumosa, but could also occur in chenopod mallee.
Yellow Swainson-pea (*Swainsona pyrophila*)	V	V	Not recorded Low-moderate potential	Suitable habitat may occur in spinifex mallee communities, particularly with Eucalyptus dumosa, but could also occur in chenopod mallee.
Amphibians				
Southern Bell Frog (*Litoria raniformis*)	E	V	Not recorded Moderate potential	Potential habitat within the disturbance area consists of small areas of semi-permanent and ephemeral ponds and ephemeral drainage swales that are part of a larger shallow wetland complex and are also connected to an oxbow lake near the Murrumbidgee River.
Birds				
Chestnut Quail-thrush (*Cinclosoma castanotus*)	V	-	Recorded	Recorded predominantly from woodland vegetation (25 records) at the West Balranald mine, Nepean mine and injection borefields.
Gilbert's Whistler (*Pachycephala inornata*)	V	-	Not recorded Moderate potential	Associated with an understorey of spinifex and low shrubs, with a relatively high number of records approximately 30 km west of West Balranald mine and scattered records the same distance to the north of the Nepean mine.
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	V	-	Recorded	Recorded at the Nepean mine and in various locations outside of project area closer to Murrumbidgee River.
Hooded Robin (south-eastern form) (*Melanodryas cucullata cucullata*)	V	-	Recorded	Recorded at various locations along the Nepean access road near the Nepean mine and injection borefields.
Little Eagle (*Hieraaetus morphnoides*)	V	-	Recorded	Ten observations in and around project area (all components) and additional records outside of the project area.
Major Mitchell's Cockatoo (*Cacatua leadbeateri*)	V	-	Recorded	Twelve observations in and around the project area, becoming more frequent with increasing distance to the north.
Malleefowl (*Leipoa ocellata*)	E	V	Recorded	Three active mounds and scattered prints at the proposed West Balranald mine along with recent mounds and many old mounds. Prints along access road to the south of Nepean mine. Two old mounds scattered throughout the Nepean mine.

Table 12.3 Threatened species recorded or with the potential to be impacted by the project

Common name	TSC Act	EPBC Act	Likelihood of occurrence	Description
Pied Honeyeater (*Certhionyx variegates*)	V	-	Possible record Moderate potential	A single possible record within the West Balranald mine.
Plains-wanderer (*Pedionomus torquatus*)	E	V	Possible record Moderate potential	Possible call between Sites WB7 & WB 8.
Redthroat (*Pyrrholaemus brunneus*)	V	-	Recorded	Recorded in 13 locations from shrubland between the West Balranald mine (northern area) and injection borefields.
Regent Parrot (*Polytelis anthopeplus monarchoides*)	E	V	Recorded	Six observations of between one and twenty individual birds were made over the course of a week. All six observations were of birds flying overhead or foraging on lerp around the Sturt Highway approximately 10 km south of the West Balranald mine area. Known to breed in this habitat along the Murrumbidgee River.
Spotted Harrier (*Circus assimilis*)	V	-	Recorded	Various records (12) distributed throughout and outside the project area.
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	Recorded	Eleven records from West Balranald mine, injection borefields and Nepean mine becoming more common with distance north. All records from woodland areas.
White-fronted Chat (*Epthianura albifrons*)	V	-	Recorded	Fifteen records predominantly in shrubland areas at the northern end of the West Balranald mine. Records extend to borefield injection areas along the Nepean access road.
Mammals				
Bolam's Mouse (*Pseudomys bolami*)	E	-	Not recorded Moderate potential	Occurs in chenopod shrubland plains or low mallee woodland where there is a developed understorey. Records occur adjacent to project area at Wampo Station.
Greater Long-eared Bat (*Nyctophilus corbeni*)	V	-	Recorded	Trapped using a harp trap along the Nepean access road at the junction of the injection borefields and approximately 6.5 km west of the West Balranald mine (southern area).
Inland Forest Bat (*Vespadelus baverstocki*)	V	-	Recorded	Possible, probable and definitive echolocation calls throughout most of project area.
Little Pied Bat (*Chalinolobus picatus*)	V	-	Recorded	Various echolocation records concentrated within woodland areas throughout project area. Large number of captures and activity was recorded at the injection borefields in an area of vegetation type 8 Belah – Chenopod Woodland. One dead bat was found in Tin Tin property shearer's quarters east of West Balranald mine.
Southern Ningaui (*Ningaui yvonneae*)	V	-	Recorded	All captures were made in or adjacent to the Nepean mine, mostly within the Wampo SMCA. Vegetation type 1 Spinifex Dune Mallee Woodland provides favoured habitat.
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	Recorded	Probable and possible echolocation records throughout project area.

Table 12.3 Threatened species recorded or with the potential to be impacted by the project

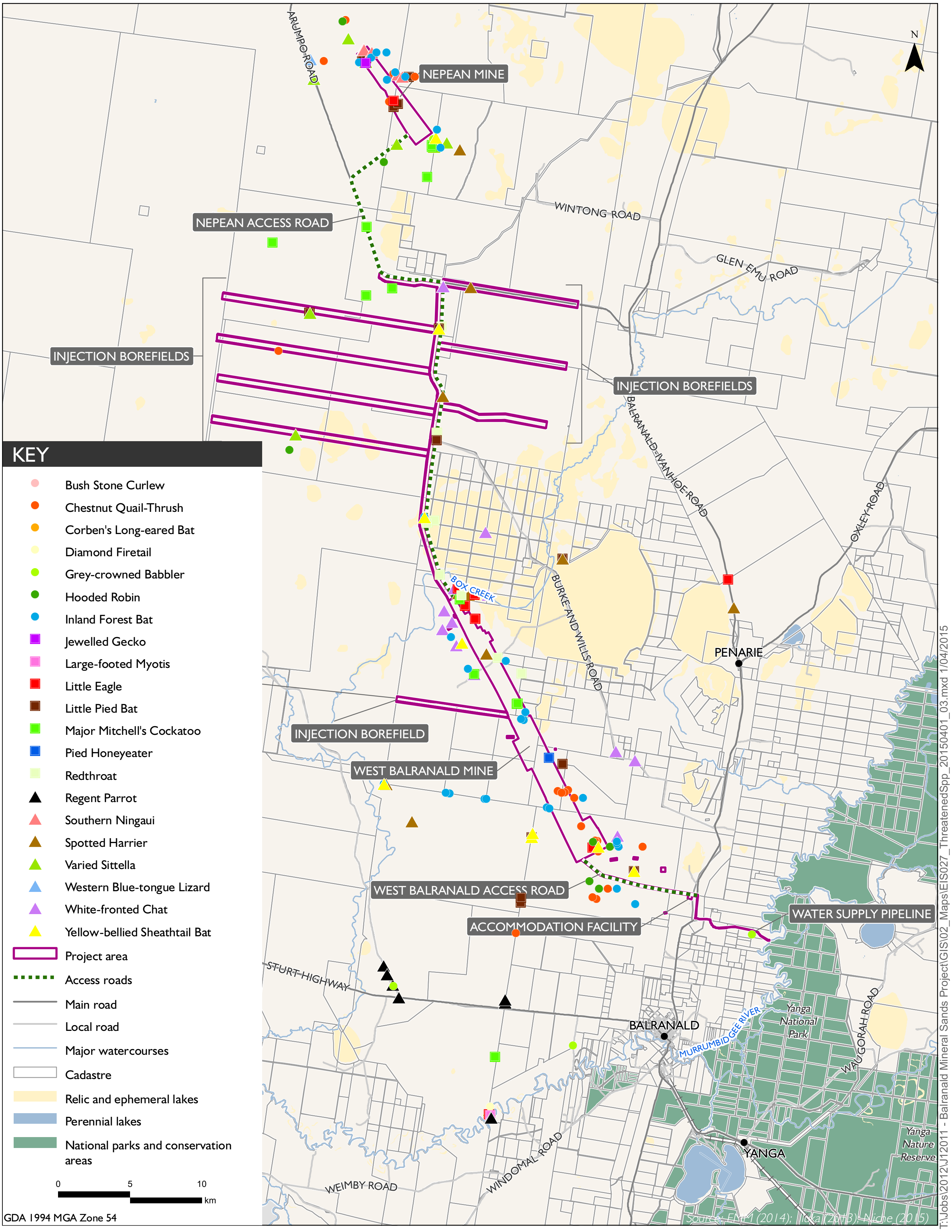
Common name	TSC Act	EPBC Act	Likelihood of occurrence	Description
Western Pygmy Possum (*Cercartetus concinnus*)	E	-	Not recorded Moderate potential	Found in mallee shrubland either dominated by spinifex or with an understorey of tea-tree and also in belah in a mixed woodland with a well developed understorey of saltbush. Several captures were made in the Wampo Conservation Area to the north of the project area in 2000-2001. Suitable habitat may occur in 7 Belah – Pearl Bluebush Woodland and 8 Belah – Chenopod Woodland.
Reptiles				
Bardick (*Echiopsis curta*)	E	-	Not recorded Moderate potential	The species is particularly common in areas of Spinifex with potential habitat occurring within vegetation type 1 Spinifex Dune Mallee Woodland in the project area.
Jewelled Gecko (*Diplodactylus elderi*)	V	-	Recorded	Recorded at five sites in and around the Nepean mine area in Spinifex Mallee.
Mallee Worm-lizard (*Aprasia inaurita*)	E	-	Not recorded Moderate potential	Previous atlas record within the West Balranald mine and several records north of the Nepean mine. Inhabits semi-arid, mallee woodlands on red sands. Often shelters in sand, beneath mallee stumps, in leaf litter or in the nests of ants and other insects; thought to be dependent on spinifex.
Western Blue-tongued Lizard (*Tiliqua occipitalis*)	V	-	Recorded	A single record approximately 4 km west of the Nepean mine (northern extent).

Note: V-vulnerable, E-endangered.

No threatened populations were identified within the project area and none are considered likely to occur.

None of the identified vegetation types in the project area meet the description of any TECs listed under the TSC Act or EPBC Act. However, the *Acacia melvillei* Shrubland in the Riverina and Murray-Darling Depression bioregions EEC, was recorded close to the project area, sporadically along sections of the Balranald-Ivanhoe Road verge and reserve, north of Balranald town for approximately 3 to 4 km. The final design of the water supply pipeline was chosen in part to avoid impacts on this TEC.

The Lowland Murray River aquatic ecological community (AEC) listed under the NSW Fisheries Management Act 1994 (FM Act), occurs in the Murrumbidgee River associated with the water extraction point for the project. The water extraction would be managed under the Murrumbidgee River WSP which implements rules of water usage to protect the environment. The Murrumbidgee River WSP allocates water for users and the environment, and as such manages water usage to ensure there is no minimal to the Murrumbidgee aquatic ecology.



Recorded threatened species locations

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Figure 12.4

12.3 Impact assessment

12.3.1 Direct impacts

The Balranald Project would result in the disturbance to approximately 5,160.5 ha of native vegetation. A further 186.1 ha of exotic pasture and existing cleared land would be developed as a result of the Balranald Project. The total of the disturbance area is approximately 5,346 ha. The area of each vegetation community to be impacted in each part of the project area is shown in Table 12.4.

As no TECs occur, the significance of remnant native vegetation to be impacted was assessed based on the distribution of vegetation types within the locality (20 km radius of the project area) (Table 12.4). Vegetation type 1 Spinifex Dune Mallee Woodland was the least extensive (9,486 ha) community within the locality, with the project impacting 5.6% of its local extent. Impacts to chenopod communities (Vegetation types 3 Black Bluebush Low Open Shrubland and 4 Pearl Bluebush Low Open Shrubland) would be approximately 2.5%, while the project would impact less than 1% of the remainder of vegetation communities within the locality.

Table 12.4 Conservation significance of remnant native vegetation in the disturbance area

Vegetation type	Per cent cleared in CMA	Disturbance area (ha)	Approximate extent in locality (ha)	Per cent of project disturbance in locality
1 Spinifex Dune Mallee Woodland	5%	536.4	9,486.0	5.6%
2 Chenopod Sandplain/Swale Mallee Woodland	30%	2,051.5	347,279.3	0.6%
3 Black Bluebush Low Open Shrubland	10%	284.9	55,476.2	2.5%
4 Pearl Bluebush Low Open Shrubland	10%	1,072.1		
5 Bladder Saltbush Low Open Shrubland	40%	558	203,165.9	0.3%
6.Old Man Saltbush Shrubland	90%	19.8		
7 Belah – Pearl Bluebush Woodland	20%	114.8	43,160.3	1.3%
8 Belah – Chenopod Woodland	20%	438.7		
9 Black Box – Chenopod Open Woodland	15%	6.9	23,606.2	0.03%
10 River Red Gum Woodland	35%	3.8	58,889.2	0.01%
11 Flat Open Claypan/Derived Sparse Shrubland	50%	73.6	0	0
Total		**5,160.5**	**741,063.10**	**0.72%**

The only identified highly cleared vegetation type (90% cleared) in the disturbance area is 6 Old Man Saltbush Shrubland, according to CMA clearing estimates in the OEH *BioMetric Vegetation Type Database*. Only a small proportion of the disturbance area (19.8 ha) contains this community and overall, the community has limited conservation significance within the project area in its present form and condition due to past and ongoing disturbance.

The disturbance area includes SMCAs that have been set aside as a form of environmental conservation reserve for the clearing of vegetation in the development of farming land for the purposes of cultivation. Approximately 1,179 ha of a total of 27,723 ha (or 4.25%) of the SMCAs would be impacted by the project.

12.3.2 Indirect impacts

Indirect impacts may be experienced on areas outside of or adjacent to the project area as a result of mine construction and operation. Such impacts would largely operate on a short to medium timeframe (i.e. the life of the mine), and would be minimised where possible through management procedures. A range of indirect impacts are likely to, or could occur as a result of the Balranald Project:

- increased spreading of weed propagules;
- erosion or sedimentation in areas adjoining construction and operational activities;
- increased noise, dust and light from mine construction and operational activities;
- loss of connectivity and fragmentation of habitats at a regional scale through clearing of intact areas of native vegetation within the disturbance area;
- increased edge-effects for surrounding vegetated areas; and
- changes in vegetation composition and structure as well as available fauna habitats due to altered fire regimes (more or less frequent fire).

The indirect impacts are variable in terms of the extent they may occur from the disturbance area. In developing the disturbance area, a series of informal buffers were applied to account for a range of geotechnical and logistical constraints, and to provide some flexibility to account for minor changes during design. The following general buffer distances were adopted when developing the disturbance areas for the West Balranald and Nepean mines:

- West Balranald mine: the disturbance area was based on providing an approximate 200 m wide buffer from the location of infrastructure, with reduced buffers of 100 m and 50 m adopted in areas of high risk for heritage significance and identified Aboriginal cultural heritage sites, respectively.
- Nepean mine: the disturbance area was based on an approximate 200 m wide buffer from the location of infrastructure.

Based on these buffers, approximately 33% of the project area at the West Balranald mine (ie 1,000 ha), and 43% of the project area at the Nepean mine (ie 350 ha) have been incorporated into the disturbance area, and are considered to cover indirect impacts, although these are conservatively assessed as direct impacts in this report. Mitigation measures proposed in Section 12.4 would further reduce any potential indirect impacts. It is anticipated that most of which would remain undisturbed but would allow for flexibility during detailed design.

For other project elements, the disturbance area was calculated as follows:

- West Balranald access road: a corridor of approximately 150 m wide was surveyed which comprises the project area. Within this corridor, a disturbance area of 60 m wide has been adopted, although the actual area of disturbance is likely to be less in some areas.

- Nepean access road: a corridor of 50 m wide was surveyed which comprises the project area. Within this corridor, a disturbance area of 40 m wide has been adopted. Of the total 39 km length of the Nepean access road, approximately 22 km is existing public roads (Burke and Wills Road and Arumpo Road) which would generally not result in disturbance outside the existing road corridor.

- Injection borefield: a total of eight injection borefields are included in the project area. Each borefield is approximately 400 to 500 m wide and contains two 50 m wide corridors containing linear groundwater infrastructure. Therefore a 100 m wide corridor (ie 2 x 50 m corridors) for each borefield was adopted as the area that would be directly impacted.

- Accommodation facility: a disturbance area of 7 ha was adopted that would be directly impacted.

- Water supply pipeline: a corridor of 40 m wide was surveyed which comprises the project area, and a disturbance area of 15 m wide was adopted that would be directly impacted.

- Gravel extraction areas: a total disturbance area of 42 ha was adopted that would be directly impacted.

12.3.3 Impacts to threatened biodiversity

i Threatened and aquatic ecological communities

No TECs listed on either the TSC Act, or the EPBC Act occur within the project area, or would be impacted by the Balranald Project. As such, assessments of significance are not required or completed.

No adverse impacts are anticipated for the Lower Murray River AEC listed under the FM Act. Water extraction at the Murrumbidgee River would be licenced through the Murrumbidgee River WSP, which manages water usage to ensure there is minimal impact to the Murrumbidgee aquatic ecology. The pump design would minimise disturbance and mitigation measures would reduce indirect impacts from pump installation.

ii Threatened flora

No threatened flora species were recorded in the disturbance area. However, seven species may occur and be impacted by the Balranald Project. State, and where required, Commonwealth assessments of significance were completed for these species. The assessments concluded that significant impacts were unlikely for any of the flora species:

- approximately 1,630 ha of potential habitat for the Mossgiel Daisy (*Brachyscome papillosa*) would be impacted by the Balranald Project, which is approximately 0.8% of available habitat in the locality;

- approximately 295.6 ha of potential habitat for the Winged Peppercress (*Lepidium monoplocoides*) would be impacted by the Balranald Project, which is approximately 0.2% of available habitat in the locality;

- approximately 1,934.7 ha of potential habitat for the Chariot wheels (*Maireana cheelii*) would be impacted by the Balranald Project, which is approximately 0.7% of available habitat in the locality;

- approximately 2587.9 ha of potential habitat for the *Pterostylis cobarensis* would be impacted by the Balranald Project, which is approximately 1.4% of available habitat in the locality;

- approximately 3,118 ha of potential habitat for the Bitter Quandong (*Santalum murrayanum*) would be impacted by the Balranald Project, which is approximately 1.7% of available habitat in the locality;
- approximately 2,499 ha of potential habitat for the Slender Darling Pea (*Swainsona murrayana*) would be impacted by the Balranald Project, which is approximately 1.5% of available habitat in the locality; and
- approximately 2,588 ha of potential habitat for the Yellow Swainson-pea (*Swainsona pyrophila*) would be impacted by the Balranald Project, which is approximately 1.2% of available habitat in the locality.

iii Threatened fauna

Twenty-six threatened fauna species listed under the TSC Act are likely to be affected by the Balranald Project. Some of these are also listed under the EPBC Act. State, and where required, Commonwealth assessments of significance were completed for these species. The assessments concluded that a significant impact was likely for one of these fauna species and possible for five species (refer to Table 12.5).

Table 12.5 Threatened fauna with the potential for significant impacts

Scientific name	Status		Significance of impact
	TSC Act	EPBC Act	
Bardick	E	-	Significant impact not likely
Bolam's Mouse	E	-	Significant impact not likely
Chestnut Quail-thrush	V	-	Significant impact not likely
Corben’s Long-eared Bat	V	-	Significant impact not likely
Gilbert's Whistler	V	-	Significant impact not likely
Grey-crowned Babbler	V	-	A significant impact is possible
Hooded Robin (south-eastern form)	V	-	Significant impact not likely
Inland Forest Bat	V	-	Significant impact not likely
Jewelled Gecko	V	-	A significant impact is possible
Little Eagle	V	-	Significant impact not likely
Little Pied Bat	V	-	A significant impact is possible
Major Mitchell's Cockatoo	V	-	Significant impact not likely
Mallee Worm-lizard	E	-	A significant impact is possible
Malleefowl	E	V	A significant impact is likely
Pied Honeyeater	V	-	Significant impact not likely
Plains-wanderer	E	V	Significant impact not likely
Rainbow Bee eater		M	Significant impact not likely
Redthroat	V	-	Significant impact not likely
Regent Parrot	E	V	Significant impact not likely
Southern Bell Frog	E	V	Significant impact not likely
Southern Ningaui	V	-	Significant impact not likely
Spotted Harrier	V	-	Significant impact not likely
Varied Sittella	V	-	Significant impact not likely
Western Blue-tongued Lizard	V	-	A significant impact is possible

Table 12.5 Threatened fauna with the potential for significant impacts

Scientific name	Status		Significance of impact
	TSC Act	EPBC Act	
Western Pygmy Possum	E	-	Significant impact not likely
White-fronted Chat	V	-	Significant impact not likely
Yellow-bellied Sheathtail-bat	V	-	Significant impact not likely

A biodiversity offset strategy has been developed to compensate for the unavoidable and significant impacts on threatened fauna and their habitat (Section 12.4.3).

One additional migratory species listed under the EPBC Act, the Rainbow Bee-eater (*Meropus ornatus*), may be impacted by the project. The assessment of significance for this species identified that a significant impact is unlikely for this species.

No aquatic fauna would be impacted by water extraction, pump installation and operation. No further assessment was completed for aquatic species.

No critical habitat listed under the TSC Act or EPBC Act would be impacted by the Balranald Project.

12.3.4 Cumulative impacts

Cumulative impacts can arise from the compounding activities of a single operation when considering past, current and future activities in an area. Cumulative impacts assessed the total impact resulting from incremental impacts (including both direct and indirect impacts) from the project when added to other existing and proposed developments in the locality and region.

The Balranald Project would add to the impacts that will result from the Atlas-Campaspe Mineral Sands Project which will be located to north of the Balranald Project. The Atlas-Campaspe Mineral Sands Project requires the clearance of approximately 4,158 ha of mostly native vegetation, progressively over approximately 20 years. Vegetation to be impacted mainly comprises Belah-Rosewood Woodland (2,035 ha) and Linear Dune Mallee (1,040 ha). These are different communities to the project area, which will require clearing of mainly vegetation type 2 Chenopod Sandplain/Swale Mallee Woodland (2,051.5 ha) and 4 Pearl Bluebush Low Open Shrubland (1,072.1 ha).

Despite this, cumulative impacts on threatened species habitat would result in the locality and region from the two projects. This includes combined impacts on habitat for Mossgiel Daisy, Winged Peppercress and Pterostylis cobariensis as well as Malleefowl, Spotted Harrier, Little Eagle, Major Mitchell’s Cockatoo, Regent Parrot, Redthroat, Pied Honeyeater, White-fronted Chat, Hooded Robin, Varied Sittella, Gilbert’s Whistler, Southern Ningaui, Western Pygmy-possum, Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Little Pied Bat, Inland Forest Bat, Bardick, Jewelled Gecko, Mallee Worm-lizard and Western Blue-tongue Lizard.

Whilst the Balranald Project and Atlas-Campaspe Mineral Sands Project would result in an increase the amount of vegetation and habitat disturbed in the locality and region, both projects would provide significant biodiversity offset packages. The packages would contribute a significant area of equivalent habitat to conservation. Further, these areas would be subject to long-term management to reduce threats and improve habitat values for affected threatened and common species in the region.

12.4 Management and mitigation

12.4.1 Avoidance

Impacts to biodiversity have been considered throughout the site selection and design process. Where possible, impacts to species and habitat of conservation significance have been avoided.

Site selection for the Balranald Project has been largely dictated by the presence of the resource within Iluka's EL. However, the location of plant, roads, stockpiles and ancillary infrastructure (eg injection borefields) have all been tailored to avoid impacts wherever possible, particularly areas with higher environmental values.

Avoidance during project design has included:

- significant re-design of the West Balranald and Nepean mine plans to maximise direct placement of overburden materials within the mine void, resulting in significantly less surface disturbance and broad-scale clearing required;
- a significant reduction of the total clearing footprint of the Nepean Mine, approximately 50% of the original mine footprint;
- reducing the footprint of the Balranald Mine (at its southern end) reducing clearing of mallee vegetation and the retention of a large east-west running vegetation corridor (at least 400 m wide) south of the disturbance area, which contains known Malleefowl habitat and also forms part of a SMCA (see Section 3.11.3);
- the alignment of the Nepean access road was changed to avoid vegetated areas, conservation areas and Malleefowl habitat;
- incorporation of local deviations to the Nepean and West Balranald access roads to avoid features eg avoidance of known Malleefowl mounds;
- utilisation of public roads such as Arumpo Road and Burke and Wills Road as far as possible reducing clearing; and
- utilisation of existing fence lines and/or property boundaries (which include existing fire break clearing lines) to minimise clearing where possible.

12.4.2 Mitigation

Management and mitigation measures would be implemented to minimise impacts on biodiversity during the construction, operation and rehabilitation stages of the Balranald Project.

A biodiversity management plan (BMP) would be prepared for the Balranald Project. It would manage various activities throughout the life of the project to protect important biodiversity values in the project area. It would cover threatened species management (including specific provisions for Malleefowl), pest and weed management, fire management and site hygiene practices. It would also include directions for survey, monitoring and management of key threatened species known or considered to be potentially impacted by the Balranald Project (in particular Malleefowl) and protocols for reporting and managing any unforeseen threatened species occurrences. Importantly, measures designed to mitigate impacts on threatened species would be monitored for success.

A key part of the BMP would be Malleefowl management. The BMP would include specific information for this threatened species including:

- methods for pre-clearing surveys for Malleefowl, which are known to use specific mound sites for breeding and would therefore benefit from further investigations identifying such sites;
- methods to monitor the status and use of mounds prior to clearing activities in the disturbance area and over the project life;
- methods for the identification of previously unidentified Malleefowl mounds in areas identified as moderate to very high potential habitat for the species;
- clearing protocols for areas where known active or recently active mounds occur;
- communications protocols for employee and contractor education;
- provisions to limit truck speeds and for signage along access roads, particularly areas close to active or recently active mounds;
- methods and communication tools to monitor road-strike and mortality of Malleefowl and disseminate information to relevant stakeholders; and
- a protocol to control bushfires, particularly those affecting mallee habitat, within or adjacent to the project area (this would form part of Iluka's emergency management plan).

Other key mitigation and management measures that would be included in the BMP are:

- protocols for clearing restrictions, informed by important lifecycle events of the threatened species known or likely to occur within the project area which are likely to be significantly impacted by the Balranald Project;
- clearing protocols in line with the Rehabilitation and Closure Strategy (EMM 2015);
- protocols for cleared vegetation to be used immediately elsewhere in Balranald Project for progressive rehabilitation; and
- the use of trittering or mulching for temporary access during construction where possible.

12.4.3 Biodiversity offset strategy

To compensate for the unavoidable impacts that remain, after impact avoidance and management and mitigation measures are employed, a biodiversity offset package would form part of the Balranald Project. The package, when finalised, would compensate for impacts on threatened species listed under the TSC Act and EPBC Act by meeting the requirements of the *Draft NSW Biodiversity Offset Policy for Major Projects* and the *Environmental Offsets Policy*.

A biodiversity offsets strategy has been prepared to describe the biodiversity offsetting approach proposed for the Balranald Project, in accordance with the SEARs. It would guide the development of the biodiversity offset package following project approval and prior to the commencement of construction works.

There is likely to be a limited timeframe between project approval and the commencement of construction for at least some aspects of the Balranald Project. Conversely, some project elements would not be developed for several years following approval. Given the nature of the development, a staged offset package is proposed, that would secure offsets to match major project stages prior to development commencing in these areas.

Stage one of the biodiversity offset package would be developed to account for and offset the impacts associated with:

- West Balranald access road;
- Nepean access road, insofar as it is adjacent to the injection borefields;
- injection borefields;
- gravel extraction sites;
- water supply pipeline; and
- first two years of mining within West Balranald mine.

Stage 2 would account for impacts associated with the remainder of the impacts, which would occur later in project staging.

The latest version of the BioBanking credit calculator BBCC for a major project has been used to determine the credits required to offset the impacts of the Balranald Project. Using this method, the impacts are conveyed as 'ecosystem credits' and 'species credits', which need to be met in the biodiversity offset package, in accordance with the FBA and *Draft NSW Biodiversity Offset Policy for Major Projects*.

The results of the calculations for ecosystem credits are presented in Table 12.6. A total of 263,563 ecosystem credits are required to be identified in the Biodiversity Offset Package to compensate for impacts to 5,160.5 ha of native vegetation which contains threatened species habitat. This represents an offset ratio of 5.5:1 for the project.

Table 12.6 BioBanking ecosystem credit calculations

Vegetation Formation (Keith 2004)	Vegetation Class (Keith 2004)	BVT	Vegetation type	Disturbance area (ha)	Ecosystem credits required	Credits per ha	Area of offset required (ha)	Indicative offset ratio
Semi-arid woodlands (shrubby sub-formation)	Dune Mallee Woodlands	LM130	1 Spinifex Dune Mallee Woodland	536.4	23,433	43.7	2,519.7	4.7:1
	Sand Plain Mallee Woodlands	LM116	2 Chenopod Sandplain/Swale Mallee Woodland	2,051.5	124,074	60.5	13, 341.3	6.5:1
	Semi-arid Sand Plain Woodlands	LM107	7 Belah – Pearl Bluebush Woodland	114.8	5,638	49.1	606.2	5.2:1
		LM108	8 Belah – Chenopod Woodland	438.7	31,356	71.5	3,371.6	7.7:1
Semi-arid woodlands (grassy sub-formation)	Inland Floodplain Woodlands	LM105	9 Black Box – Chenopod Open Woodland	6.9	361	52.3	38.8	5.6:1
Forested wetlands	Inland Riverine Forests	LM143	10 River Red Gum Woodland	3.8	151	35.0	14.3	3.8:1
Arid shrublands (Chenopod sub-formation)	Aeolian Chenopod Shrublands	LM102	3 Black Bluebush Low Open Shrubland	284.9	12,765	44.8	1,372.6	4.8:1
		LM138	4 Pearl Bluebush Low Open Shrubland	1,072	47,613	44.4	5,119.7	4.8:1
	Riverine Chenopod Shrublands	LM110	5 Bladder Saltbush Low Open Shrubland	558	14,929	26.8	1,605.3	2.9:1
		LM137	6 Old Man Saltbush Shrubland	19.8	831	42.0	89.4	4.5:1
Saline Wetlands	Inland Saline Lakes	LM124	11 Flat Open Claypan/Derived Sparse Shrubland	73.6	2,412	32.7	259.4	3.5:1
			Total	**5,160.4**	**263,563**	**-**	**28,338.3**	**5.5:1**

Note: BVT = BioMetric Vegetation Type (OEH 2011).

The results of the calculations for species credits are presented in Table 12.7. Species credit are generated for those threatened species that are not attributable to any certain habitat type in the calculations. Species credits were generated for six of the recorded species that may be impacted by the project. The remainder of recorded threatened species are regarded as Ecosystem Credit species.

Table 12.7 Biobanking species credit calculations

Species	Status TSC Act	Status EPBC Act	Significance of impact	Habitat impacted by development	Species credits required	Offset area required1	Indicative offset ratio
Southern Bell Frog (*Litoria raniformis*)	E	V	A significant impact is not likely	2 ha	26	4 ha	2:1
Little Eagle (*Hieraaetus morphnoides*)	V	-	A significant impact is not likely	5,161 ha	72,254	11,624 ha	2.3:1
Spotted Harrier (*Circus assimilis*)	V	-	A significant impact is not likely	2,028 ha	28,392	4,568 ha	2.3:1
Bolam's Mouse (*Pseudomys bolami*)	E	-	A significant impact is not likely	1,294 ha	99,638	16,590 ha	12.8:1
Western Pygmy Possum (*Cercartetus concinnus*)	E	-	A significant impact is not likely	3,118 ha	62,544	13,675 ha	4.4:1
Bardick (*Echiopsis curta*)	E	-	A significant impact is not likely	2,588 ha	46,908	12,650 ha	4.9:1

Notes: 1. Equivalent offset area (based on the OEH credit converter).

The offset requirements have also been calculated for MNES. One Commonwealth-listed species is likely to be significantly impacted by the project, the Malleefowl. To meet a 90% direct offset requirement under the *EPBC Act Offset Assessment Guide* (EPBC offset calculator), 5,000 ha of Malleefowl habitat is required (based on impacts to 2,543 ha of suitable habitat).

The Balranald Project will result in impacts to parcels of land that have been set aside as a form of environmental conservation reserve for the clearing of vegetation in the development of farming land for the purposes of cultivation, known as SMCAs. The SMCAs reserve like for like vegetation types typically at maximum ratios of 1:1.

Two SMCA's occur within the West Balranald and Nepean mine areas (Figure 3.2). Given the biodiversity values and existing land management practices within the existing SMCA areas, additional offsets to those calculated for using the BBCC will not be included in the offset package as:

- SMCA lands within the Balranald and Nepean mine areas are not currently actively managed for conservation and are subject to impacts associated with feral animal populations within these areas;
- Iluka proposes to "replace" the SMCAs with other like for like conservation areas;
- original offset ratios used to develop the SMCA areas were very low, but the offsets ratios proposed for the Balranald Project are significantly higher, ranging from 4:1 to 7.7:1; and
- offsets developed for the Balranald Project will be provided in perpetuity with management funding for genuine conservation outcomes, which would lead to a significant increase in the regional quantum of land being managed for conservation.

Where possible, like for like outcomes would be pursued for the biodiversity offset package. Should like for like vegetation types not be located, the package would consist of a similar vegetation type or one of higher conservation priority in accordance with the variation rules of the FBA.

Iluka is committed to providing and securing a suitable offset package for the project that would satisfy both the NSW and Commonwealth offset requirements. The biodiversity offset package would be prepared in consultation with OEH, DoE and other relevant stakeholders. The biodiversity offset package would primarily rely upon the acquisition of suitable lands which, through a range of possible legislative agreements, would be placed under conservation covenants and managed for conservation in perpetuity.

Considerable effort has gone into identifying potentially suitable offset sites, undertaking preliminary landholder consultation and consulting with both OEH and DoE as to the suitability of the potential offset sites. Works undertaken to date have identified that suitable offsets exist, both in quantum and type, within the vicinity of the project area. Early and regular consultation with landholders of properties containing the potential offset sites has indicated that they are willing to pursue offset site development negotiations.

The proposed offset sites would need to ensure that the biodiversity values impacted by the Balranald Project would be maintained and improved in the long-term. This would be achieved through the application of the *Draft NSW Biodiversity Offset Policy for Major Projects* and the *Environmental Offsets Policy*. As a result, the Balranald Project would:

- add significant areas of managed offsets to the existing reserve and conservation network to enhance conservation outcomes for the wider region;
- reduce grazing pressures from feral animal species and lead to improved biodiversity values through management of the offset sites;
- contain similar vegetation types and fauna habitat to what occurs within the project area with significantly more areas conserved than impacted; and
- enhance landscape connectivity in the region by the development of offset sites adjacent to existing reserves or contiguous with existing vegetated corridors.

12.5 Conclusion

Flora and fauna databases and previous reports were reviewed to identify threatened species and TECs that could potentially occur within the project area. This information aided in the development of multiple targeted field surveys conducted between October 2011 and December 2014.

Eleven native vegetation communities were identified within the project area. None of the vegetation types within the disturbance area are listed as TECs under the TSC Act or EPBC Act. As such, no significant impact would occur to any TEC would occur as a result of the Balranald Project.

No adverse impacts are anticipated for the Lower Murray River AEC as a result of water extraction from the Murrumbidgee River given that extraction would be licenced through the Murrumbidgee River WSP.

No threatened flora listed by either the TSC Act or EPBC Act were recorded within the project area. However, it is considered that seven threatened flora may be impacted by the Balranald Project. Twenty species of threatened fauna were detected during field-survey. All of these species are listed under the TSC Act and three species are also listed under the EPBC Act. Given the presence of suitable habitat or known records, a total of twenty-six fauna species have the potential to be impacted by the Balranald Project.

The Balranald Project has evolved during the course of the biodiversity investigations and a suite of measures have been designed to avoid, minimise and mitigate adverse impacts on biodiversity. However, residual impacts remain, with the project progressively clearing 5,160.5 ha of native vegetation. Significant impacts were identified for the Grey-crowned Babbler, Malleefowl, Little Pied Bat, Jewelled Gecko, Mallee Worm-lizard and Western Blue-tongued Lizard. These species are all listed under the TSC Act and the Malleefowl is also listed under the EPBC Act.

The Balranald project also has the potential for indirect impacts from erosion and sedimentation in adjacent bushland and weed invasion. However, the impact assessment has used a conservative approach and incorporated buffers into the disturbance area, which would remain largely unaffected over the life of the project, to quantify and assess such impacts.

Residual impacts would be compensated through a biodiversity offset package. A biodiversity offsets strategy has been included in this assessment and the requirements of the biodiversity offset package have been identified using the BioBanking credit calculator and in accordance with the EPBC offset calculator. The biodiversity offset package would meet the calculated requirements in accordance with NSW and Commonwealth policy, and is currently being prepared in consultation with OEH, DoE and other relevant stakeholders.

13 Aboriginal heritage

13.1 Introduction

The SEARS require an assessment of the potential impacts of the Balranald Project on Aboriginal cultural heritage. The SEARS state that this EIS must include:

- An Aboriginal cultural heritage assessment (including both cultural and archaeological significance) which must:
  - demonstrate effective consultation with Aboriginal communities in determining and assessing impacts, and developing and selecting mitigation options and measures; and
  - outline any proposed impact mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures); and

In addition, the Balranald Project was referred to DoE, which identified two key assessment requirements. The two key requirements are listed below and are the subject of a separate EIS being prepared under the EPBC Act:

- impacts on world heritage values of a declared World Heritage property listed under Section 12 and 15A of the EPBC Act; and
- impacts on the national heritage values of a National Heritage place listed under section 15B and 15C of the EPBC Act.

13.2 Assessment method

The Aboriginal cultural heritage assessment of the Balranald Project was prepared by Niche and is summarised in this chapter.

The main objectives of the assessment were to:

- identify Aboriginal heritage within the project area with a focus on sites in the areas of proposed impact including;
  - Aboriginal objects and sites;
  - Aboriginal socio-cultural sites, which may be intangible (ie not associated with Aboriginal objects);
  - areas of archaeological sensitivity (referred to as “risk layers” in the technical report);
- assess the archaeological significance of objects and sites within the areas of impact;
- assess the cultural significance of objects, sites and the landscape through consultation with the registered Aboriginal parties;
- assess the impact of the project on the identified archaeological and cultural values; and

- formulate a management strategy that is appropriate to the significance and the level of predicted impact to those sites.

The assessment was prepared by investigating the following aspects against the project area by:

- undertaking an Aboriginal Heritage Information Management System (AHIMS) search within 10 km of the project area;
- preparing a literature review of previously prepared archaeological assessment in the region, many of which had a focus on Balranald and some further afield in the Willandra Lakes region; and
- conducting field survey over three seasons to understand the landscape, verify the presence of sites and objects previously recorded on the AHIMS register and to record newly discovered sites and objects.

The assessment was undertaken in accordance with the following guidelines:

- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011);
- *Draft Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation* (DEC, 2005);
- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW 2010b) (the ACHCRs);
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010a (the Code); and
- *Burra Charter* (Australia International Council on Monuments and Sites 2013).

13.3 Existing environment

13.3.1 History and landform

The project area is located within the semi-arid zone of NSW. The climate is characterised by hot summers, cold winters and low annual rainfall. It consists of a series of dune fields and sand plains vegetated by mallee communities, and also contains brown soil undulating plains usually vegetated by saltbush, bluebush, belah and rosewood communities. Depressions and ephemeral lakes occur across the region.

Straddling two subregions; the Lachlan and Murrumbidgee Alluvial Fans, and the Scotia dune fields, the project area is characterised by dune fields, and sand plains and vegetated by mallee communities with undulating plains of brown solonised soils usually vegetated by saltbush, bluebush, belah and rosewood communities. On the margin of this system is a series of large relict lakes, remnants of an earlier landscape, fringed by lunette formations. These lunette formations are crescent-shaped, fixed dunes along the edges of relict lakes, playas and river valleys in arid and semi-arid lands.

The project area is derived from Tertiary and Quaternary sediments about 60 million years old. It is covered by ten local land systems; Arumpo, Bulgamurra, Condulpe, Guthul, Hatfield, Marma, Rata, Riverland, Wilkurra and Youhl (Soil Conservation Service of NSW 1991).

The West Balranald mine area has three dominant land systems. The Marma land system is characterised by its vaguely defined scalded drainage tracks. The Rata land system has extensive covering of saltbush and small sub-circular depressions and the Condoulpe land system is characterised by its sand plain between dune fields and Riverine Plain. The Arumpo land system is dominant in the Nepean mining area and is characterised by its parallel dunes and sand plain with narrow chalky swales.

The hydrology of the project area is poorly defined with the exception of Muckee, Pitarpunga and Tin Tin lakes, and Box Creek downstream of its confluence with Arumpo Creek. Upstream of this confluence, Box Creek is a distributary of the Lachlan River, and lacks a deeply incised channel or deep waterholes. However, when filled with water, low points in the landscape would have provided a resource-rich environment that would have been exploited by the Aboriginal people in the region.

Also present in the project area are swamp depressions and ephemeral small lakes, and a system of large relict lakes and fringing lunette formations. While there are no perennial watercourses, Box Creek, an ephemeral tributary of the Lachlan River active during major flood events, flows through the project area to the north of the West Balranald mine. Changes in the availability of water have been demonstrated in the archaeological record of Aboriginal use of the Willandra Lakes landscape. The changes in the climate and hydrology that may have effected how and where Aboriginal people used the landscape in the past would have included changes in precipitation and also channel switching of the Lachlan River further upstream. In the southern part of the project area there are extensive gently undulating riverine plains (associated with the Murrumbidgee River), and vegetation dominated by saltbush shrub lands, ephemeral grasslands and Black Box fringing cane grass depressions.

Landscapes that demonstrate geological forces from two epochs and resulting archaeological landscapes are represented within the project area; the Pleistocene, approximately 2.5 million to 12,000 years ago, and the Holocene, which started to form 12,000 years ago to the present. Pleistocene relict landforms are found in the vicinity of the northern half of the West Balranald mine area near Muckee Lake, Tin Tin Lake and Pitarpunga Lake. It is highly likely that Pleistocene relict landforms may also be present in some parts of the injection borefields.

The Holocene is generally characterised by a warmer, wetter environment until 5,000 years ago when the environment became dryer. The change in climate is reflected in the change in landforms and the archaeological landscape.

The dominant Holocene landforms in the vicinity of the project area are the linear dune fields and ephemeral creeks and channels. Dates returned from the analysis of buried soils demonstrates that the dune system as last active about 15,000 years ago (Bowler and Polach 1971).

The Pleistocene landscape preserves evidence of ancient Aboriginal occupation, as demonstrated by archaeology within the WLRWHA about 23 km from the Nepean mine (Figure 1.2) and 15 km west of the westernmost boundary of the injection borefields. Lake Mungo, which is part of the WLRWHA, has been extensively studied with respect to geomorphology, ancient environment and archaeological context, amongst other topics, the results of which have been used as a basis for the study of the project area.

13.3.2 Archaeological heritage sites

i Aboriginal Heritage Information Management System

A number of AHIMS searches were undertaken between 22 May 2012 and 5 October 2014 with the resulting return of 250 recorded Aboriginal sites within 10 km of the project area. All of these sites were recorded prior to the commencement of the Balranald Project. One site, (47-2-0192 Karra 1) was recorded in the project area. Karra 1 is an artefact scatter comprising 16 stone artefacts recorded by Murray and Stone (2011).

The majority of site features recorded in the AHIMS are stone artefacts and hearths, some mounds, shell middens, culturally modified trees, grinding grooves, fish traps and conflict sites.

The distribution of recorded sites supports the model that water sources are an important indicator of habitation with archaeological sites being abundant within the Riverland land system. Nevertheless, the absence of recorded sites can be a reflection of the lack of survey in some areas, rather than the absence of artefacts.

Table 13.1 shows AHIMS recorded site distribution by land system.

Table 13.1 AHIMS search results by land system

Land system	Number of sites	% of sites
Riverland	102	40.80
Youhl	104	41.60
Marma	24	9.60
Condoulpe	16	6.40
Arumpo	1	0.40
Mungo	1	0.40
Rata	1	0.40
Victoria	1	0.40
Total	**250**	**100.00**

ii Other registers

A search was undertaken of other heritage registers to determine if there were any registered Aboriginal heritage items within, or surrounding, the project area, including the:

- heritage schedule of the Balranald LEP;
- State Heritage Register (SHR);
- State Heritage Inventory (SHI) for government agency listings (section 170 register);
- Commonwealth Heritage List (CHL);
- National Heritage List (NHL); and
- World Heritage List (WHL).

No Aboriginal heritage items are listed within the project area within the above registers. The nearest registered item is the WLRWHA listed on both the NHL and WHL and at its closest is approximately 15 km from the Balranald project area.

iii Previous studies

Several Aboriginal heritage investigations have been conducted close to the project area. An area 5 km to the east of the project area, a section of Paika Creek and Paika Lake on Paika Station, and Box Creek and Geraki Creek on Tin Tin Station, was surveyed by Martin (2010). During this survey over 300 Aboriginal sites were recorded. Of these, special significance was placed on a historic camp on Tin Tin Station where several Aboriginal families lived during the 1950s. Other sites in abundant quantities included stone artefact scatters and hearths. Some mounds, shell middens, culturally modified trees, grinding grooves, fish traps and conflict sites were also recorded. In additional, large mounds containing baked clay and a termite mound heat retainer, ashy deposit, and rare fragments of shell were recorded.

Recent archaeological work conducted by Niche (2012) in the sand plain and relict lake land systems near Hatfield and at Ivanhoe, reported 100 Aboriginal sites including hearths, artefact scatters and isolated finds across three land systems shared with the project area (Marma, Hatfield and Youhl).

13.3.3 Regional archaeological context

Research specific to the project area is sparse and has, by necessity, drawn from the extensive body of information on Lake Mungo within WLRWHA. As with WLRWHA, the palaeo-environment of the project area influenced its current archaeological condition, thus it is important to understand the geological development that includes landforms created in the Pleistocene. Studies of lakes within WLRWHA and creek system to the north and west of the project area demonstrate a correlation between the changing climate from the Pleistocene to the Holocene, with aridity increasing to the mid-Holocene (approximately 5,000 years ago), at which point the system reaches its current semi-arid status, the climate becoming essentially what it is like today.

Regional archaeological surveys and predictive modelling has shown that riverine landforms and lunette lake systems within the Murray Basin are particularly rich in evidence of Aboriginal occupation. The WLRWHA in particular, has a long history of occupation dating back at least 40, 000 years.

Early archaeological work in the region has recorded human remains in Lake Mungo (Mungo I) dated to approximately 30,000 years ago during the Pleistocene period (Bowler 1998). Due to this being the earliest known Australian Aboriginal archaeological site it could not be substantiated until a further two remains were found and dated to a similar period (Johnson and Clarke 1998). Numerous human remains have since been found in the sand dunes of the Willandra Lakes area.

Aboriginal occupation surrounding the project area fluctuated with the changes in climate and availability of water and food. As Lake Mungo dried approximately 14,500 years ago due to drainage diversion and climate change, Aboriginal people may have developed new dry land economies (Bowler 1998; Hiscock 2008). During the past 1,500 to 2,000 years the climate became wetter suggesting increased occupation of hinterland areas of western NSW in the late Holocene period (Rhodes et al. 2009; Shiner 2009).

The project area lies within the Mutthi Mutthi, Barindji and Yitha Yitha cultural/linguistic territory (Tindale 1974, Horton 1994).

The pre-contact environment was modified by the settlement and practices of the incoming European population. Pastoral practices such as sheep and cattle grazing resulted in tree clearances along the water courses, erosion of soils and the subsequent changes to the water system. The earliest and largest land holding in the region was Paika Station, established by George Hobler in 1845 but it was not until the 1850s that permanent water management was established that the pastoralists began living in the region on a permanent basis. Since then, extensive areas of mallee have been cleared, resulting in increasing erosion, which in turn can have a significant effect on archaeological site visibility and integrity.

Major changes have included the construction of dams, fences and roads and other rural infrastructure, and in particular over stocking of pastoral holdings in the late 1800s, causing severe erosion. In many parts of the project area mallee has been cleared for use as a resource, and also to provide land for broad acre dry land crops.

Further compounding the damage to the landscape by the hard hooves of cattle and sheep, the environment went through a major drought and the introduction of feral animals (eg rabbits). The downturn in wool prices resulted in the increase in sheep numbers. Later cereal cropping saw the ploughing of soils, further affecting the archaeological integrity in some areas within the project boundary.

Erosion caused by European farming practices has resulted in significant impacts to the soils on lunettes dispersing and moving down slope on wetting. On the back plain landforms, sheet erosion has led to the topsoil being stripped and the formation of hard-surfaced scalds. Some of these scalds also contain patchy residual soil mounds around their margins. These residual soil mounds may preserve an original soil profile beneath a cap of windblown sediment.

13.4 Impact Assessment

13.4.1 Methodology

i Aboriginal stakeholder consultation

Aboriginal stakeholders were identified in accordance with OEH's *Aboriginal cultural heritage consultation requirements for proponents* (DECCW, 2010) and the *Draft Guidelines for Aboriginal cultural heritage impact assessment and community consultation* (DEC, 2005c).

The guidelines outline a four stage consultation process, as follows:

- Stage 1 – notification of the project and registration of interest;
- Stage 2 – presentation of information about the project;
- Stage 3 – gathering information about cultural significance; and
- Stage 4 – review draft cultural heritage assessment report.

a. Stage 1 - Notification

Stage 1 of the consultation requirements was to identify potential cultural knowledge holders for the Balranald Project. Notifications were sent on 19 December 2011 to the following groups of interest:

- Queanbeyan OEH Environmental Protection and Regulation Group Office, Landscape and Aboriginal Heritage Protection (South);
- Balranald Local Aboriginal Land Council (LALC);
- Office of the Registrar (under the NSW *Aboriginal Land Rights Act 1983*);
- National Native Title Tribunal (NNTT) South-East and Central Registry;
- Native Title Services Corporation Limited (NTSCORP);
- BSC; and
- Lower Murray Darling CMA (Lower Murray Darling CMA now the NSW Government Local Land Service Western).

Written responses were received from Balranald LALC, Lower Murray Darling CMA, NTSCORP, NNTT and OEH and a list of potential cultural knowledge holders was compiled from the information provided.

Advertisements were published in the *Riverine Grazier* and *The Guardian* on 7 March 2012, and the *Mildura Weekly* on 9 March 2012 inviting any additional Aboriginal parties to register an interest in the Balranald Project.

As a result of the above consultation, the following six organisations and persons became registered Aboriginal parties (RAPs) to the Balranald Project:

- Balranald LALC;
- Kay Dowdy (nee Murray);
- Daniel Kelly Snr on behalf of the Balranald Aboriginal Health Service (BAHS) representing Mutthi-Mutthi people;
- Yarkuma Aboriginal Support Service; Balranald
- Ali Maher - National Koorie Site Management; and
- Paul Charles - Kullila Site Consultants.

Yarkuma Aboriginal Support Service Balranald was subsequently removed as a RAP on 14 November 2012 at the organisation's request.

b. Stage 2 – Presentation of project information

Information about the Balranald Project was presented to the RAPs on a number of occasions via information sessions and letters.

Following registration, invitations were extended to the RAPs to attend a project information session held in Balranald town on 14 June 2012. The purpose of the information session was to provide information on the project and methodology of the Aboriginal cultural heritage assessment.

After this information session held 14 June 2012, the RAPs were provided with a letter (letter dated 30 May 2012) inviting feedback on the project information provided and the proposed methodology for the assessment. Twenty-eight days were allowed for RAPs to suggest protocols to be adopted into the information gathering process, to provide feedback on the assessment and survey methodology and highlight any other matters such as issues or areas of cultural significance that might affect, inform or refine the methodology.

c. Stage 3 - gathering information about cultural significance

Stage 3 began with an invitation to RAPs to provide Iluka with any advice on the cultural significance of places or sites that may be affected by the Balranald Project at the information session on 14 June 2012. Twenty-eight days were provided to the RAPs to respond.

A written response to the request for feedback on the proposed survey methods were received from Daniel Kelly Snr (on behalf of the BAHS representing Mutthi Mutthi people). Mr Kelly's comments included identification of previous sites such as deposits, middens, culturally modified trees, burial and stone tool use found in the area, the importance of mining to the local economy and need for full participation of Mutthi-Mutthi people in all aspects of the cultural heritage assessment.

A letter (dated 6 August 2012) requesting information about Aboriginal heritage cultural values and a cultural assessment was sent to RAPs inviting them to participate in an evaluation of cultural significance.

Expressions of interest for involvement in the field surveys were received from RAPs.

Representatives from the following RAPs advised that they were available to participate in the Aboriginal cultural heritage field survey:

- Balranald LALC;
- BAHS representing Mutthi-Mutthi people;
- National Koorie Site Management; and
- Kullila Site Consultants.

Requests for information on pre-existing cultural values within the project area were made to the RAPs in the letter of invitation (14 June 2012) and during the information session held 14 June 2014 as well as via an additional letter dated 6 August 2012. No written responses or expressions of interest were received from any RAPs regarding the above issue.

Archaeological survey was conducted in three programs and four phases: July to August 2012, September to October 2013, and October and December 2014. BAHS representing Mutthi Mutthi people, National Koori Site Management and Kullila Site Consultants participated in all the surveys. BLALC participated in all surveys except the surveys in December 2014.

d. Aboriginal stakeholder meetings

A project information seminar was held at Balranald with all RAPs invited on 14 June 2012. The presentation provided information to the RAPs about the project, the assessment process, assessment timeframe and to provide the proposed assessment methodology for comment. In addition, the RAPs were informed of their roles and responsibilities during this information seminar.

At the completion of the first field survey and subsequent assessment, a workshop was hosted on 16 October 2012 in Balranald by Iluka in association with Niche. A summary of the results, the assessment process, field results and impacts were presented with the intention of receiving feedback from the RAPs. Some verbal feedback was received from a number of RAPs present at the meeting, with the main themes of discussion being:

- site avoidance where possible;
- appropriate management of any objects collected; and
- the strong desire of the RAPs to remain informed and involved in the decision making processes with regard to Aboriginal cultural heritage matters.

e. Stage 4 - review draft cultural heritage assessment report

A project update and invitation to a consultation meeting was sent to the RAPs on 27 January 2015 with the meeting held on 26 February 2015. Representatives of Balranald LALC, National Koori Site Management and Kullila Site Consultants were present at the meeting. BAHS representing Mutthi-Mutthi people could not attend and sent their apologies. The draft Aboriginal cultural heritage assessment was presented at the meeting and the management and mitigation measures were discussed.

Hard and digital copies of the draft ACHA and the meeting presentation were provided to all RAPs. Follow up calls and emails were made to all RAPs between 18 and 27 March. Written and verbal feedback on the draft report was provided by:

- Balranald LALC;
- BAHS representing Mutthi-Mutthi people;
- National Koori Site Management; and
- Kullila Site Consultants.

ii Site prediction modelling

Site prediction modelling was undertaken to identify the likelihood of Aboriginal occupation based on environmental factors, land systems and previous archaeological assessments from western NSW. The following factors were considered when predicting sites of Aboriginal occupation:

- access to water;
- climatic conditions, landscapes which are well protected from both extremes of the elements;
- access to raw material for the production of stone tools;
- level ground with good drainage;
- elevation above cold air currents and lingering front prone valley systems often with good views of the river flats and water courses; and
- adequate fuel supply.

Holocene sites are predicted to occur along the Box Creek floodplain and have been estimated to be no older than 500 to 3,000 years old. It is possible that buried archaeological deposits are also preserved within the alluvial deposit of the Box Creek catchment and burials may be present in the areas of deep soil accumulation such as lunettes and alluvium.

Evidence of much older occupation may also be possible within the project area, as indicated by the presence of a burnt emu egg shell recovered and dated as 17,000 year old date to the east of the project area from site WB66 on the eastern Muckee Lake lunette.

Quarries for stone tool manufacture are unlikely to occur within the project area as there are no known quarries of stone suitable for artefact manufacture located in or near the project area. Calcrete and carbonate nodule deposits have been recorded but would have primarily used as heat retainers and were unlikely to have been used to fashion tools.

Environmental conditions and historical impacts such as grazing are likely to cause difficulty in establishing the date of some of the sites. However, a range of features that can be directly dated through radiocarbon and optically stimulated luminescence (OSL) and relatively dated through association may exist to provide clear dates for occupation in the project area.

The project area has the potential to contain very ancient Aboriginal cultural sites as a result of the landforms having formed either in the Pleistocene or Holocene period. In some cases, landforms such as lakeside lunettes and source bordering dunes deposited during the Pleistocene may be present in the project area and may contain ancient Aboriginal sites, potentially with ages similar to those found in the WLRWHA. Portions of the lunette on the western shoreline outside the project area have gullying and sheet wash erosion. Pelletal clay is evident in these locations and may be indicative of a Pleistocene landscape.

The project elements that are associated with such landforms are West Balranald mine, injection borefield 3, injection borefield 5, injection borefield 8 and the Nepean access road. During the Pleistocene the lakes would have provided a valuable resource rich area for Aboriginal communities during these more arid times. The importance of these ancient lake systems and the lake side landscapes are reflected in the listing of the WLRWHA.

However, for the most part, the project area consists of sand plains and dune systems which stabilised around 8,000 – 5,000 years ago. It is assumed that Box Creek has not been an active channel in terms of floodplain deposition for the majority of the Holocene, but prior to this would have actively meandered across the plains. In most cases Aboriginal cultural and archaeological sites are therefore assumed to be Holocene in age, and will be associated with the ephemeral watercourse of Box Creek and the episodic lakes and depressions which fill during local rain events, or major flood events.

iii Aboriginal cultural heritage field survey

A basic landscape analysis was undertaken prior to the field survey to divide the area into transects for pedestrian survey. The analysis included constraints such as access to land, potential rainfall impacts and surface visibility. The focus of the survey was on areas of greatest exposure such as scalds, eroded surfaces, openings in vegetation and cuttings.

Survey participants flagged suspected archaeological material. Sites were recorded using a hand-held GPS with an average accuracy of ± 7 m and recording on proforma data sheets. Discrete sites were distinguished by a separation of 40 m or more. The AHIMS site recording form guided the site and artefact attribute recording process for up to 300 artefacts per site. Where site size exceeded 300 artefacts, an estimate was made.

The survey team spaced themselves 10 to 20 m apart and moved slowly forward in a line scanning the ground, flagging any cultural materials identified as they passed over them. As the field survey moved on, a larger amount of time was dedicated to areas of higher visibility to enable comprehensive detection to take place. This method was used across all transects unless the transect was an irregular shape in which case the survey was customised to ensure a uniform survey was undertaken.

A team of archaeologists followed the survey team through compiling records for subsequent analysis and characterisation of the area's local archaeology. The senior archaeologist made all final decisions in respect to environmental description of the transect and the content of cultural materials flagged by the survey team.

Survey was conducted in over four separate field trips in 2012, 2013 and 2014, as follows:

- October 2012 - consisted of 25 field days with three archaeologists and five Aboriginal sites officers provided by the RAPs. About 628 ha of a 10,137 ha investigation area was surveyed;

- October to November 2013 - consisted of 12 field days with four archaeologists and six Aboriginal sites officers provided by the RAPs. About 963 ha of a 4,000 ha investigation area was surveyed;

- October 2014 - consisted of 11 field days with four archaeologists and six Aboriginal sites officers provided by the RAPs. About 841 ha of a 2,600 ha investigation area was surveyed; and

- December 2014 - consisted of 12 field days with eight archaeologists and eight Aboriginal sites officers provided by the RAPs. About 1,125 ha of a 3,300 ha investigation area was surveyed.

13.4.2 Survey results

Across the surveys approximately 2,119.9 ha of the 9,964 ha project area was surveyed. This coverage equates to a representative sample of 21.3% of the project area. Survey coverage of land systems within the project area such as Gulthul, Hatfield, Marma, Rata, Riverland, and Youhl was between 32% and 64%.

The survey coverage is represented in Table 13.2 and Aboriginal sites in the Balranald Project Aboriginal heritage database (BPAHD) is shown in Table 13.3.

Table 13.2 Survey coverage of the land systems

Land system	Land system area in project area (ha)	Area surveyed in project area (ha)	Average visibility (%)	Average exposure (%)	Effective coverage area (ha)	Effective coverage (%)
Arumpo	773	9.9	66.0	34.0	2.2	22.4
Bulgamurra	2.0	0	60.0	40.0	0.0	0.0
Condoulpe	2,058.4	26.5	55.7	35.4	5.2	19.7
Gulthul	1,965.3	526.2	60.7	30.0	95.8	18.2
Hatfield	976.1	331.3	61.9	41.8	85.7	25.9
Marma	1,262.2	347.8	60.8	39.6	83.7	24.1
Rata	2,560.4	722.0	53.8	34.9	135.4	18.8
Riverland	17.8	10.8	60.0	40.0	2.6	24.0
Wilkurra	75.2	7.6	60.0	40.0	1.8	24.0
Youhl	274.2	137.8	61.0	29.5	24.8	18.0
Total	**9,964.5**	**2,119.9**	**57.9**	**35.8**	**439.4**	**20.7**

Table 13.3 Summary of Aboriginal sites in the BPAHD by site type

Site type	Sites in BPAHD		Sites in project area		Sites in disturbance area	
	No.	%	No.	%	No.	%
Artefacts	230	41.97	162	42.30	114	44.53
Isolated artefact	246	44.89	166	43.34	94	26.72
Artefacts and hearth	42	7.66	34	8.88	30	11.72
Hearth	22	4.01	16	4.18	14	5.47
Hearth and isolated artefact	5	0.91	4	1.04	3	1.17
Artefacts, hearth, culturally modified tree and PAD*	1	0.18	1	0.26	1	0.26
Artefacts, mound, mound scatter, hearth, hearth scatter and PAD	1	0.18	0	0	0	0
Culturally modified tree	1	0.18	0	0	0	0
Total	**548**	**100.00**	**383**	**100.00**	**256**	**100.00**

*Note: * PAD = Potential archaeological deposit; a location considered to have a potential for subsurface archaeological material.*

The number of sites within each project element is presented in Table 13.4.

Table 13.4 Summary of Aboriginal sites within the BPAHD by project element

Project element	No. sites in project area	No. sites in disturbance area
Injection borefield 3	50	15
Injection borefield 4	23	7
Injection borefield 5	88	34
Injection borefield 5 and Nepean access road	7	7
Injection borefield 6	23	20
Injection borefield 7	22	11
Injection borefield 8	59	55
Injection borefield 9	31	29
Injection borefield 10	7	5
Gravel extraction area C	1	1
Injection borefield 8 and Nepean access road	1	1
Nepean access road	1	1
West Balranald mine	70	70
Sub-total	383	256
Outside project area but within 100 m	314	-
Outside project area	134	-
Sub-total	**168**	**-**
Total	**548**	**256**

In total, 548 Aboriginal sites were identified during the survey. Four hundred and seventeen (417) are located in or within 100 m of the project area with 256 of those sites located within the disturbance area (Table 13.4). An additional 127 sites are in locations that may be indirectly impacted. The Balranald Project heritage database relates to all sites identified during the survey, within and outside the project area.

The location of the Aboriginal sites identified during the survey in and around the project area can be seen in Figure 13.1.

i Summary of survey results

Three hundred and eighty (383) sites were recorded in the project area with 256 occurring in the disturbance area. Archaeological survey was also conducted in areas that were formerly part of the project area but have since been excised, bringing the total recorded number of sites to 548.

Analysis by land systems within the project area indicates the highest artefact density per hectare was recorded on the Marma land system (7.1), followed by the Hatfield (4.7) and Youhl (4.5), Rata (2.7) and Perekertin (2.3), Wilkurra (2.0), Gulthul (1.0), Bulgamurra (0.5), Arumpo (0.1), Condloupe (0.1) and Riverland (0.1). The sample size for the remaining land systems was relatively low. In the cases of the Wilkurra, Bulgamurra and Arumpo land systems, the results reflect overall trends reported in local and regional archaeological assessments.

Of all the sites identified, 89.8% contained a single site feature (ie only stone artefacts or only hearths) and 10.2% of the sites contained two or more site features (ie hearths and artefacts or hearths, artefacts, culturally modified tree and PAD).

Stone artefacts, both as isolated occurrences and open artefact scatters, were the most common site type and the most frequent site feature. Hearths, both as isolated occurrences and clusters of hearths, were the second most frequent site type and site feature. One culturally modified tree was identified as part of the much larger site of West Balranald 40 (WB40). This site, WB40, is a high density archaeological complex containing a high frequency and diversity of stone artefacts (1,030), hearths, a culturally modified tree and PAD. It has been assessed as one of the most significant sites in the project area for its research and scientific value and for the potential for Pleistocene and Holocene deposits to exist. This site is partially located within the disturbance area of the West Balranald mine.

The majority of sites contained between one and ten stone artefacts. Fewer than 10% of sites contained between 11 and 50 Aboriginal stone artefacts (118 sites). Eleven sites contained between 50 and 100 artefacts. Thirteen sites contained between 100 and 200 artefacts. Eight sites contained more than 200 artefacts. The eight largest sites include one that is not in the project area (UD26). The largest sites are made up of a number of types occurring singly or as combinations and include artefact scatters, hearths with charcoal, termite heat retainers and burnt emu shell.

Of all the sites identified, the presence of artefact types such as backed artefacts, geometric microliths, cores and angular fragments indicate knapping floors (where tools were manufactured). The density of these sites, and the type of artefacts they comprise, provide the opportunity for detailed site and artefact analysis. Some of the sites have not had their boundaries determined as the surveys were restricted to the project area that was current at the time. Other sites represent extensive occupation through high artefact counts and hearths.

Artefacts were represented in silcrete, quartzite, sandstone, chert and rhyolite materials. Artefact classes included grinding stone fragments, retouched flakes, flakes, cores, anvils and hammerstones. The presence of residual soils and rills suggest the presence of PADs.

Hearths are a common feature across the landscape. One hundred individual hearths were recorded in 63 sites. Seventy were assessed to have fair to excellent dating potential (these are recorded on the BPAHD thus includes hearths in areas that are now excluded from the project boundary). They are in various forms that included intact, disturbed (retain a central concentration of heat retainers), partially buried, exposed or buried, scattered (central concentration is lost and does not have a clear focal point) and remnant (doughnut shaped without a central focus). The hearths that remain intact or partially buried offer excellent dating potential.

Heat retainers are burnt clay and sediment, heated termite mound material and calcrete and are a component of a hearth, although they can also represent a natural fire or decay. Many of the sites with heat affected material are associated with woodland areas and box trees and it is not clear if the resulting material is of natural or human agency.

Culturally modified trees also occur across the landscape in the region. One culturally modified tree was recorded in the project area but outside of the disturbance area at site WB40. At least another two are located outside the project area in site B15.

ii Significance assessment

a. Assessment criteria

The *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011) requires that a 'clear description of the heritage values present across the area of the proposed activity' be presented, and be articulated back to the information collected during the assessment process, in particular to any submissions received from RAPs. It also advises that 'the assessment of values is a discussion of what is significant and why'. The purpose of a statement of significance is to create a comprehensive assessment of values and significance by considering and stating the values identified under each of the value categories defined by the Burra Charter, namely, social values, historic values, scientific values, and aesthetic values.

An assessment of significance was completed for each of the Aboriginal sites. The significance assessment was guided by the principles of the *Burra Charter* (Australia International Council on Monuments and Sites 2013) and the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011). The following scientific significance assessment criteria were used:

- research potential - which considers the contribution of a site to the understanding of Australia's cultural history or human occupation;
- rarity - which is determined based on the degree a site demonstrates common aspects of the archaeological record; the fewer site or artefact types, the rarer they are;
- representativeness - which considers how well a site represents, or is an example of other sites in the same class or category;
- aesthetic - which relates to the sensory responses people have to a place and which may be associated with the setting of a site; and
- educational potential - which considers the ability of a site to portray easily recognisable archaeological features and therefore be used to inform people of the past.

iii Site condition

The condition of each site was assessed to inform the assessment of significance. Four categories were used:

- excellent - pristine condition, unaffected by natural erosion or impacts of human agency in the preservation of its contents and structure;
- good - slightly affected by erosion or impacts of human agency and its contents and structure are probably more than 70% intact;
- fair - affected by erosion or impacts of human agency and its contents and structure are probably less than 50% intact; and
- poor - severely affected by erosion or impacts of human agency and its contents and structure are probably less than 25% intact.

The bulk of the sites fell within the poor to fair site condition categories and is reflective of the impacts of grazing and historic land use within the project area.

iv Significance grading

Using the criteria above, sites were graded in terms of level of significance from low to high. This grading would directly inform the management measures for the archaeological sites within the project area. Grading was determined by using the sites at Lake Mungo as examples of high value.

Each recorded site was assigned a significance level of high, moderate or low, defined as follows:

- High - the site or object has value because it contains archaeological and/or contextual features which through further investigation may significantly contribute to our understanding of the past, both locally and on a regional scale. These features include, but are not limited to: Aboriginal ancestral remains; the site's relationship with landscape features or other Aboriginal archaeological sites or areas of identified heritage importance; diagnostic archaeological or landscape features that inform a chronology; and a very large assemblage of stone artefacts associated with other features such as oven remains or shell midden. Such sites would be relatively rare, and would be representative of a limited number of similar sites that make up this class; hence they derive high representative and rarity values.

- Moderate - the site or object derives value because it contains features, both archaeological and contextual, which through further investigation may contribute to our understanding of the local past. These features include, but are not limited to: the relationship with landscape features or other Aboriginal archaeological sites or areas of identified heritage importance; diagnostic archaeological or landscape features that inform a chronology; and a relatively large assemblage of stone artefacts. The presence of a diverse artefact and feature assemblage, and connectedness with landscape features and other notable sites provide relatively higher representative and rarity values than sites of low significance.

- Low - the site or object contains only a single or limited number of features, and has no potential to meaningfully inform our understanding of the past beyond what it contributes through its current recording (ie no or low research potential). The site or object is a representative but unexceptional example of the most common class of sites or objects in the region. Many more similar examples can be confidently predicted to occur within the project area, and in the region.

v Summary of site significance

Of the total 383 sites (comprised of one or more elements) one is of high significance (WB40), 61 are of moderate significance and 321 are of low significance.

As previously discussed, WB40 is partially located within the disturbance area of the West Balranald mine.

vi Statement of significance

Social value: The project area has social significance to the Aboriginal community because it contains archaeological sites and traditional resources that establish a link between the past and present Aboriginal use of the land.

Aesthetic value: The project area has low aesthetic value. The project area generally consists of undifferentiated plains and dunes of chenopod shrub and Mallee lands respectively. In many areas natural landscapes have been highly modified by over stocking and land clearing for pastoralism and broad acre grain crops.

Historic value: The project area has no identified historic values.

Scientific (archaeological) value: The project area contains landscapes which have high and moderate archaeological value, but for the most part contains landscapes that are of low archaeological value. The high and moderate value areas include the Box Creek distributary stream of the Lachlan River (at the northern end of the West Balranald mine) and areas of relict lake fringes and depressions associated with the northern injection borefields. These parts of the project area are significant because they may reveal important details about how and when Aboriginal people lived in this area, and how Aboriginal settlement of the area relates to, and informs what is known of Aboriginal history in adjoining areas, including the WLRWHA. In particular the areas of high and moderate significance within the project area may provide a story of how people have utilised the area, and how this utilisation relates to the active and inactive phases of Box Creek's history and the episodic filling history of the lakes as the availability of water changed from the terminal Pleistocene to the present. As well as providing information about the chronology and nature of Aboriginal settlement of the region, the project area may also provide additional information on the local and regional use and distribution of resources, such as raw materials for making stone tools.

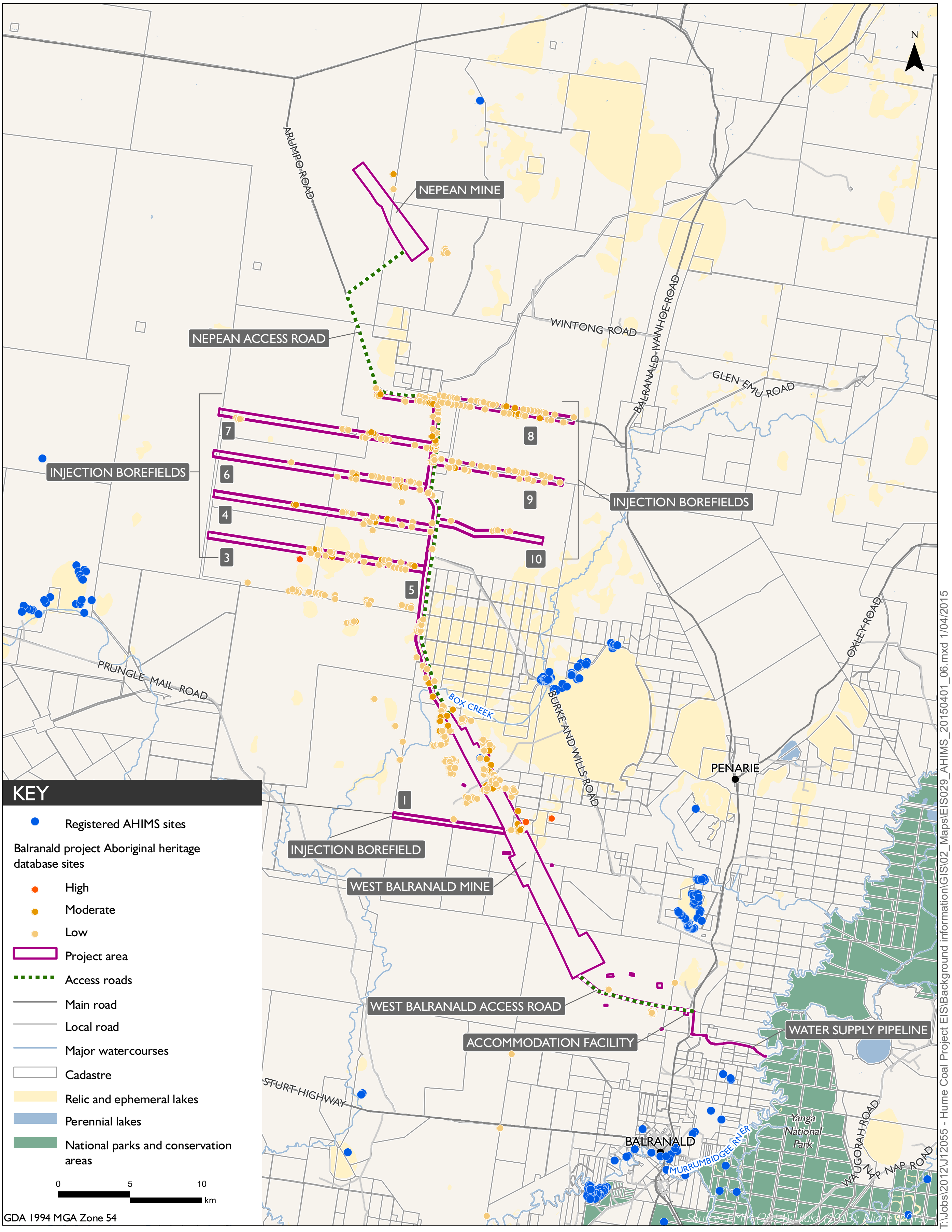
13.4.3 Impact assessment

The impact assessment was based on ascertaining consequences of harm on the value of the Aboriginal sites based on the type and degree of harm predicted. Three consequences of harm were predicted:

- total loss of value – no heritage values would remain subsequent to the harm;
- partial loss of value – some heritage values would remain subsequent to the harm; and
- no loss of value – there would be no harm, and no loss of value.

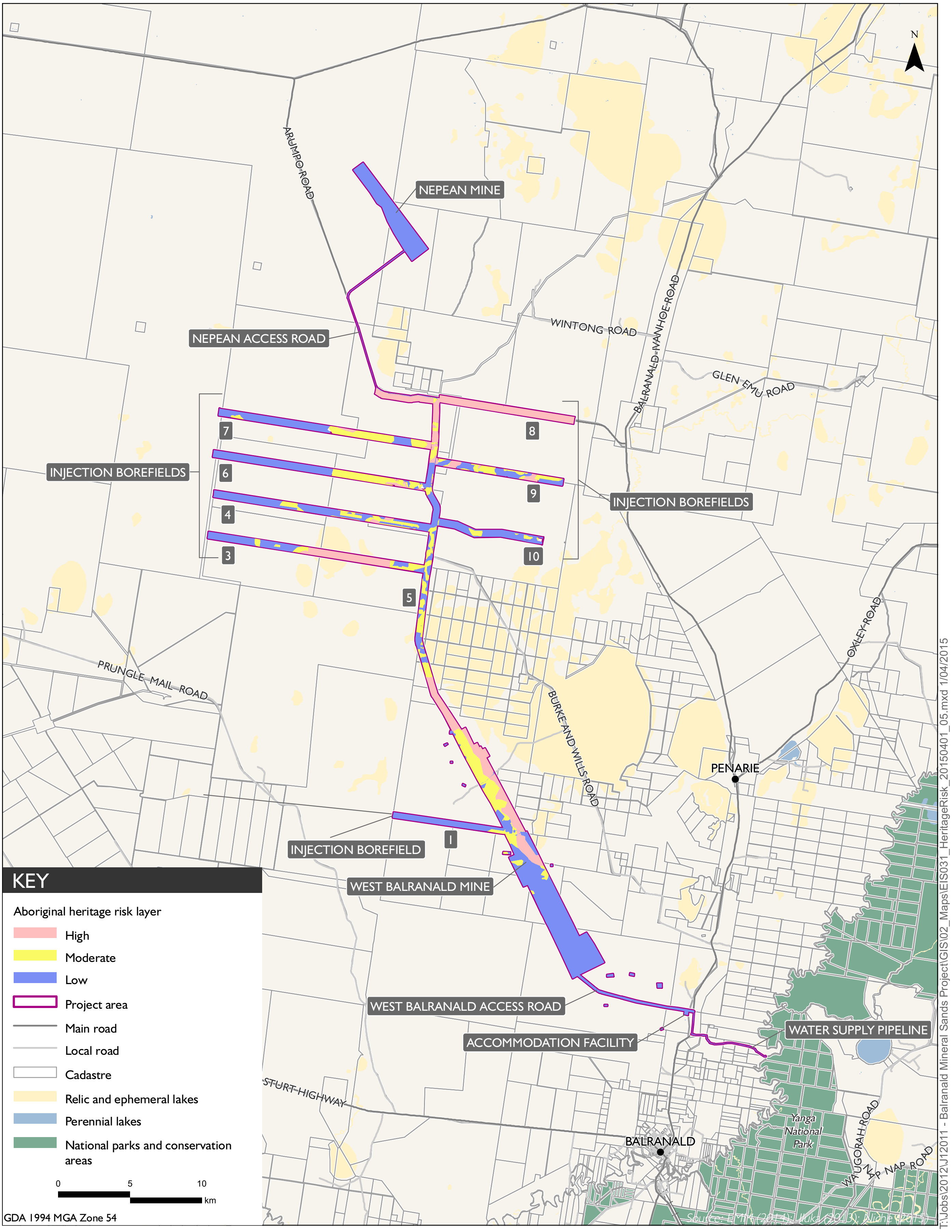
Impacts have been defined as direct and indirect, as follows:

- direct harm - harm associated with surface disturbance activities is anticipated to cause either a total or partial loss of heritage value at affected sites, and would have a cumulative or landscape impact of partial loss of values for the area as a whole, including:
  - disturbance of the ground surface or soil units (eg vegetation clearance and topsoil stripping, soil removal and excavations) in areas with Aboriginal objects on the surface or within the soil profile; and
  - changes to a site or place's context that has secondary impacts to the site or place, resulting in the loss of cultural values;
- indirect harm - potential indirect harm that the proposed activities include but are not limited to:
  - increased visitor traffic;
  - erosion; and
  - changes to the groundwater levels which may affect the longevity of specific Aboriginal site types that are groundwater dependent (eg culturally modified trees).



Aboriginal sites in and around the project area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 13.1



Aboriginal heritage risk layers in the project area

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Figure 13.2

Direct harm would only occur within the disturbance area.

For the purposes of the impact assessment, where a portion of a site falls within the disturbance area, that portion of the site is considered to be directly impacted while the remaining portion of the site is considered to be indirectly impacted. Any direct impact to a site is considered to result in a loss of value. Any site that is directly impacted would therefore be considered to have resulted in, at minimum, a partial loss of value. Where 50% or less of a site would be directly impacted, the loss of value to the site is considered partial. Where more than 50% of a site would be directly impacted, the loss of value is considered to be total.

The Balranald Project will cause the loss of heritage values to sites of high, moderate and low archaeological significance. Table 13.5 summarises the expected loss of value (total, partial or none – as required by the *Code of practice for the archaeological investigation of Aboriginal objects in NSW*) for sites in the project area based on their archaeological significance.

One site of high archaeological significance would suffer a partial loss of value from the proposed project activities. Sites of low archaeological significance would suffer the greatest relative total loss of values, while sites of moderate significance would suffer proportionally higher partial loss of value than the sites of low significance. This is because the sites of low significance are generally smaller in area than the sites of moderate significance, and because efforts have been made to avoid the sites of moderate and high significance as far as possible, hence resulting in partial, rather than total, loss of value.

Table 13.5 Summary of archaeological significance and corresponding loss of value

Archaeological Significance	Total loss of value	Partial loss of value	No loss of value	Total number of sites
High	0	1	0	1
Moderate	18	32	7	57
Low	188	35	93	316
Total	206	68	100	374

i Aboriginal archaeological risk layers

The archaeological sensitivity of the project area was investigated through extensive background research and survey. An archaeological model was created to assess the likelihood of Aboriginal sites and artefacts being present in the project area by analysing the number and density of recorded sites and their relationship with environmental proxies. A computer model, which utilised digital datasets including the Western NSW land system mapping, NSW hydrology and drainage mapping, aerial imagery and vegetation mapping, was prepared with the results overlain on the project area. The definition of the risk layers is provided in Table 13.6.

The results are the Aboriginal heritage risk layers, created for the purposes of informing management and mitigation measures for the project (Figure 13.2). Appropriate responses to identified impacts in the project area are guided by the existence of landscapes and the expectation of the nature and value of the archaeology that may be present.

Table 13.6 Archaeological risk layer definitions

Risk Layer Rating	Character of Risk Layer Rating
High	Landscape features associated with sites of moderate to high significance and frequent low density sites of low significance. These landscape features may be lunettes, dunes, scalds and pans associated with depressions, relict lakes, relict creeks and vegetation suggesting shallow water tables. Land systems such as Marma, Hatfield, Youhl, Rata and Peretkin frequently contain these features.
Moderate	Landscape features associated with frequent isolated and low density sites, often of low significance. The landscape features may be dunes, scalds or pans and differ from the high risk rating due to their increasing distance from water or resource and/or the limited nature of that resource. Land systems such as Marma, Hatfield, Youhl, Rata and Peretkin frequently contain these features.
Low	Landscape features associated with low archaeological potential or infrequent, isolated Aboriginal objects of low significance. These landscape features are typically characterised by disturbed land or limited temporary or permanent water sources, mallee dunefields, calcareous rises or saltbush plains with few pan, scalds, soaks and depressions. Land systems such as Arumpo, Bulgamarra, Condoulpe and Gulthul often contain these landscape features.

13.4.4 Impacts by project area

i West Balranald

The West Balranald Mine has 70 recorded sites within its boundary, all of which have the potential for impacts. One site, WB40, is of high significance and will have approximately 2% (1 ha) of its total surface area directly impacted by mining activities.

A little over 40% of the land within the West Balranald Mine has been assessed to be within the moderate to high archaeological risk layers. The identification of moderate to high archaeological risk must also consider that avoiding known sites is likely to result in the identification of additional sites of equal or greater value.

ii Nepean mine

All of the land contained with the Nepean mine is categorised as having low archaeological risk. No known Aboriginal sites have been identified in the Nepean mine. Aboriginal sites may occur in this area but they will most likely be infrequent, small, fall within the low significance category and represent occasional discard rather than frequent or long term occupation of the area.

iii Injection borefields

Three-hundred and three (303) Aboriginal sites were recorded in the injection borefields, with the proposed activities potentially harming 182 of those sites. Indirect impacts are predicted for 36 sites and 85 Aboriginal sites will not be impacted by the proposed activities.

A total of 44 of the 303 sites have been assessed to be of moderate significance.

Optimisation of the injection borefields through the placement of pipelines, access tracks, turkey's nests and pumps etc should consider that approximately 48% of the borefields area is considered to be of moderate to high archaeological risk. The identification of moderate to high archaeological risk must also consider that avoiding known sites is likely to result in the identification of additional sites of equal or greater value.

iv Access roads

Nine known sites will beimpacted by the Nepean access road.Four of the sites are of moderate scientific significance and five of low scientific significance. No known sites will be impacted by the West Balranald Access Road.

v Other areas

No known Aboriginal sites will be impacted by the accommodation facility, water supply pipeline and gravel extraction areas.

13.4.5 Cumulative impacts

Cumulative impacts are the successive, incremental and combined impacts of one or more activities on the environment, including cultural heritage values. Taken in context with pre-existing development and conservation in the region, the Balranald Project would have some effect on the cumulative impact on the Aboriginal cultural heritage of the local area and region. Pre-existing impacts in the region include land clearing and agricultural activities, and the recently approved Atlas-Campaspe Mineral Sands Project. Existing conservation areas in the regional area include the WLRWHA, Mungo National Park, Yanga National Park and the SMCAs.

The pre-existing disturbance to the landscape within the project area and local area represent significant ground surface modification. Given that the majority of the archaeological record is found on deflated surface in the project area and surrounds, it is considered that there are high levels of pre-existing harm to the archaeological record, and to the cultural heritage of the region. In conservation areas this harm has been arrested, and in the WLRWHA, managed to conserve heritage values.

The dominant character of the archaeological record of the local area was previously not well known. The results of the Aboriginal cultural heritage assessment indicate that the project area generally contains surface stone artefact sites with low numbers of artefacts. For the most part, these sites are interpreted to be Holocene in age. In some places, the project area has the potential to contain both larger and/or older sites, although these are very unlikely to be as significant as the sites in the WLRWHA. For the most part, potential impacts of the Balranald Project involve the harm of relatively high numbers of low value archaeological sites. This is not considered a significant cumulative impact because the results of the Aboriginal cultural heritage assessment indicate that similar archaeological sites, of similar value, would be present in commensurate environmental contexts immediately adjacent to the project area, and throughout the local area and region. Some areas of high and moderate archaeological sensitivity would be impacted by the Balranald Project, however such areas would also occur adjacent in the local area, and throughout the region.

When considered in context of the large areas of land that have been subject to agricultural activities in the region, areas of conservation that are already present within the region, and the relatively confined nature and flexibility of some parts of the Balranald Project, the cumulative impact of the project on Aboriginal cultural heritage is considered to be low and within acceptable limits.

13.4.6 Impacts on Willandra Lakes Region World Heritage Area

The Aboriginal cultural heritage assessment considered impacts of the Balranald Project on the WLRWHA.

There are no development activities associated with the Balranald Project that would directly or indirectly impact on the cultural heritage values of the WLRWHA. The closest point of the project area to the WLRWHA is the western boundary of the injection borefields which lie between 15 km and 16 km from the eastern boundary of the WLRWHA. At its closest point the Nepean mine area is approximately 23 km south east of the boundary of the WLRWHA, while the West Balranald mine is located approximately 34 km away. The results of other technical assessments undertaken as part of the EIS, such as noise, air quality, visual and groundwater, indicate that there would be no direct or indirect impacts on the WLRWHA. The traffic assessment indicates that while project related transport will utilise roads that provide access to the WLRWHA, these movements will not have an impact on the capacity or function of these roads.

In summary, the location of the project area is distant enough from the WLRWHA for there to be no foreseeable direct or indirect physical impacts on the WLRWHA from the Balranald Project.

In addition to the above, based on current archaeological and geomorphic evidence, including extensive field survey during the Aboriginal cultural heritage assessment, there are no identified outstanding examples of landscapes or geomorphic features located in the project area that have similar values to the WLRWHA. According to current evidence and known Aboriginal cultural knowledge, there are no places or sites located within the project area that represent exceptional testimony to a cultural tradition or to a civilisation which is living or which has disappeared.

Finally, assessment of the Aboriginal archaeological and cultural landscape of the project area with national heritage criteria did not identify any archaeological or cultural sites of National significance and none that are considered to have the same scientific significance of sites or places in the WLRWHA.

13.5 Management and mitigation

13.5.1 Aboriginal cultural heritage management plan

An Aboriginal cultural heritage management plan (ACHMP) would be prepared for the Balranald Project in consultation with RAPs. It would detail management of Aboriginal heritage values throughout the life of the project.

The management plan would detail the following hierarchy of management and mitigation:

- avoidance of known sites/high risk areas during mine plan development (to be ongoing during further detailed design);
- for unavoidable impacts, undertake mitigation via:
    - salvage excavation and landscape characterisation of areas of research interest;
    - salvage surface collection in high and moderate risk layers;
    - unmitigated harm in low risk layer;
- protocols that prescribe the involvement of the RAPs in the preparation, implementation and ongoing review and maintenance of the ACHMP.

- protocols that prescribe the involvement of the RAPs in cultural heritage works conducted under the ACHMP.

- provisions for the management of culturally sensitive information;

- a communications protocol that describes clear methods of communication, including expectations of suitable notification and response times, between Iluka and the RAPs;

- procedures to establish and maintain (via frequent scheduled updates) a GIS database of Aboriginal heritage sites, their boundaries, their management status and archaeological risk identified within the project area (ie the BPAHD;

- a protocol for the protection, storage, management and access arrangements for (short and long-term) salvaged Aboriginal objects informed by the wishes of the RAPs;

- a protocol for the discovery and management of human remains within the project area, including stop work provisions and notification protocols;

- procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the project, (ie management measures should give consideration to the site's heritage values);

- protocols for heritage awareness training to be incorporated into the mine site inductions for both employees and sub-contractors who may be conducting works within the project area which have the potential to impact on any Aboriginal heritage site or are working in areas of moderate to high archaeological risk;

- a procedure for documenting, communicating and incorporating into the ACHMP a record of authorised impacts to sites, and a record of sites avoided (eg through detailed design);

- procedures for activities when working in moderate and high archaeological risk layers, including but not limited to:

  - constraining vehicle and people movements to defined disturbance footprints (to minimize the risk of disturbance outside of the footprints);

  - implementation and maintenance of controls for sediment, erosion and waterflow through instruments such as the ESCP;

  - avoidance of known sites and areas of high risk (via, temporary fencing, signage etc);

- procedures for the preparation and staged implementation of the archaeological research and salvage programs;

- a regular review process for the ACHMP that:

  - considers operational adequacy and efficacy;

  - updates the management detail of the ACHMP as the project progresses;

  - reviews the compliance of the ACHMP outcomes against the project approval; and

  - initiates a mechanism for amendment in accordance with the above protocols.

13.5.2 Surface salvage collection and management of areas based on risk rating

A detailed surface salvage collection program for sites directly disturbed as a result of the Project. The scope of the surface salvage collection program will include the following:

- high risk layer areas - pre-impact block surface clearance and surface salvage of sites within the disturbance area - collection of all visible surface artefacts and collection of dating samples;
- moderate risk layer areas - pre-impact block surface clearance and surface salvage of sites within the disturbance area - collection of all visible surface artefacts and collection of dating samples; and
- low risk layer areas - no management.

Details of the surface collection program should be contained in the ACHMP.

13.5.3 Archaeological research and salvage excavation program

A detailed archaeological research and salvage program for Aboriginal heritage sites and the archaeological risk layers that will be subject to surface disturbance as a result of the project. The research and salvage program must include the detail of the proposed salvage works, including the following:

- methods for accurate location recording and surface salvage collection of artefacts;
- methods for accurate location recording and collection of dating samples;
- methods for the undertaking of salvage excavations in those areas of research interest that will be impacted by the final disturbance footprint that include:
  - exact and appropriate locations of the proposed excavations, including their nature and size;
  - justification – both scientific and economic - of appropriate scale and scope of the works;
  - geomorphic analysis by a qualified geomorphologist;
  - collection of charcoal and OSL dating samples;
  - collection of soil samples;
  - collection of artefacts and other cultural materials (if present);
  - reporting procedures; and
- details of the research and salvage program should be contained in the ACHMP.

The management and mitigation measures to inform the ACHMP are summarised in Table 13.7.

Table 13.7 Recommended management of risk layers with unsurveyed area and known sites

Risk layer	Unsurveyed area	Known sites
High	Avoidance where possible, where not possible: • staged block pre-impact surface collection and clearance with point provenance of artefacts; and • collection of dating samples from hearths.	Avoidance where possible, where not possible: • selection of a sample of landscapes associated with high significant known sites and key focus research areas for salvage excavation; • pre-impact surface collection/clearance point provenance of artefacts; and • collection of dating samples from hearths.
Moderate	Avoidance where possible, where not possible: • staged block pre-impact surface collection and clearance with point provenance of artefacts; and • collection of dating samples from hearths.	Avoidance where possible, where not possible: • selection of a sample of landscapes associated with moderate significant known sites and key focus research areas for salvage excavation; • pre-impact surface collection/clearance point provenance of artefacts; and • collection of dating samples from hearths.
Low	No management and mitigation measures.	Avoidance where possible, where not possible, no management and mitigation measures.

13.6 Conclusion

The Aboriginal cultural heritage assessment examined predicted impacts to Aboriginal sites and objects from the Balranald Project. The results were obtained through an investigation of the existing environment, previous archaeological assessment, field survey and Aboriginal stakeholder consultation.

The cultural heritage survey was conducted over three field programs between 2012 and 2014. The field programs involved a total of 535 person days of survey. A total of 548 Aboriginal sites were identified across all archaeological investigations for the Balranald Project. These sites were added to the BPAHD. Approximately 76% of the identified Aboriginal sites (417) are located in or within 100 m of the project area. Three hundred and eighty three Aboriginal sites are located within the project area and 256 Aboriginal sites are located within the disturbance area.

The project area has social significance to the Aboriginal community because it contains archaeological sites and traditional resources that establish a link between the past and present Aboriginal use of the land. The project area contains landscapes which have high and moderate archaeological value, but for the most part contains landscapes that are of low archaeological value. The high and moderate value areas include the Box Creek distributary stream at the northern end of the West Balranald mine and areas of relict lake fringes and depressions at the northern injection borefields and Muckee Lake. These parts of the project area are significant becaus ethey may reveal important details about how and when Aboriginal people lived in this area, and how Aboriginal settlement of the area relates to, and informs what is known of Aboriginal history in adjoining areas, including the WLRWHA. In particular the areas of high and moderate significance within the project area may provide a story of how people have utilised the area and how this relates to the active and inactive phases of Box Creek's history, and the episodic filling history of the lakes as the availability of water changed from the terminal Pleistocene to the present. As well as providing information about the chronology and nature of Aboriginal settlement of the region, the project area may also provide additional information on the local and regional use and distribution of resources, such as raw materials for making stone tools.

An impact assessment was completed for the sites to be impacted by the Balranald Project and management and mitigation measures considered. As a result of the archaeological investigation the following recommendations were made:

- preparation of an ACHMP;
- surface salvage collection and management of areas based on risk rating for sites directly disturbed as a result of the Project; and
- development of an archaeological research and salvage excavation program.

The ACHMP will provide detailed procedures for the management of Aboriginal sites and for the unexpected discovery of Aboriginal objects and human remains. Aboriginal objects or sites subject to impacts from the project will be recorded and collected, and through agreement with all stakeholders, a keeping place will be established to ensure the care and control of the collection.

14 Water resources

14.1 Introduction

The SEARs require an assessment of the potential impact of the Balranald Project on water resources. The SEARs state that this EIS must include:

- an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the EPA's and NSW Office of Water's requirements and the *NSW Aquifer Interference Policy*;
- an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users;
- a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;
- demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);
- a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo; and
- a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.

The water assessment for the Balranald Project was prepared by EMM (Appendix K). The results are summarised in this chapter for surface and groundwater resources.

The water assessment was prepared using a number of technical assessments which have been appended to the water assessment, including:

- Groundwater dependent ecosystems impact assessment report (CDM Smith 2015; Appendix J);
- Acid and metalliferous drainage risk and management implications for mining and closure of the West Balranald Mineral Sands deposit (Earth Systems 2015; Appendix Q);
- Balranald Project DFS1 groundwater modelling (Jacobs 2015; Appendix I);
- Regional groundwater monitoring information, commenced in 2011 on a quarterly basis;
- Iluka 2015 Balranald Mineral Sands Project, Radiation risk assessment April 2015 (Appendix S);
- Summary of landholder discussions as part of the beneficial use assessment (Land and Water Consulting 2014); and
- Balranald Mineral Sands Project surface water management report (WRM 2015; Appendix H).

Groundwater modelling undertaken by Jacobs, as presented in the groundwater modelling report, was independently peer reviewed by Hugh Middlemis.

The water assessment was undertaken in accordance with the following regulations, methods and guidance documents:

- *Australian Groundwater Modelling Guidelines* (NWC 2012);
- *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000);
- Basin Plan (MDBA 2012);
- *Groundwater Monitoring and Modelling Plans - Information for prospective mining and petroleum exploration activities* (NOW 2014);
- *Guidelines for the Assessment and Management of Groundwater Contamination* (DEC 2007);
- *National Water Quality Management Strategy: Guidelines for Groundwater Protection in Australia* (ANZECC/ARMCANZ 2000);
- the AIP (NOW 2012);
- *NSW State Groundwater Policy Framework Document* (DLWC 1997); and
- *Murray-Darling Basin groundwater quality sampling guidelines, Technical Report No. 3* (MDBC 1997).

14.2 Existing environment

14.2.1 Surface water

i Features

The Murrumbidgee and Murray rivers are the major permanent surface water features in the vicinity of the project area (Figure 3.2). The Lachlan River terminates at the Great Cumbung Swamp, approximately 42 km east of the project area. Further upstream this is a major permanent surface water feature. The Murrumbidgee and Murray rivers provide key water resources for large populations within the Murray Darling Basin including town water, agricultural and environmental supplies. The Murrumbidgee River is about 13 km south-east of the West Balranald mine, and flows in a south-westerly direction, to its confluence with the Murray River about 40 km to the south-west of Balranald town. A small part of the project area (the water supply pipeline) is located on the western flood plain of the Murrumbidgee River.

Due to the climatic conditions (ie low rainfall and high evaporation), flat landscape, and large areas of permeable soils, there is little locally derived runoff in the project area and no permanent surface water sources. Extremely heavy local rainfall events are capable of filling local depressions, including dry relic beds and creating temporary flow in drainage features, such as Box Creek.

Within the project area is Box Creek, an ephemeral watercourse that receives distributary flows from the Lachlan River. Box Creek has no defined beds and flow has only occurred in Box Creek on several occasions in the last 60 years in association with heavy local rainfall or large flooding events. The vast majority of the Box Creek catchment area, which covers most of the project area, drains into dry lakes or depressions; significant and sustained rainfall is needed for Box Creek to flow (WRM 2015).

ii Drainage

To the far north-east of the project area, Merrowie and Middle creeks, overflow distributaries of the Lachlan River, drain into Box Creek. However only if the flood levels are high enough and sustained for a long enough period will flood water from Middle and Merrowie Creeks drain into Box Creek. Muckee, Pitarpunga and Tin Tin Lakes are on the eastern side of the project area, and Box Creek drains into these lakes. Run off in the vicinity of West Balranald mine also typically drains north into these Lakes. If these lake become full (they are typically dry) flow will drain into Box Creek downstream of the lakes, to the west of the project area. After merging with Arumpo Creek, Box Creek flows into the Murrumbidgee River, approximately 30 km south-west of the project area.

The vast majority of the Box Creek catchment area drains into dry lakes or depressions; very little to no local runoff enters Box Creek. Under pre mining conditions it is likely that any runoff from the project area would drain via shallow overland sheet flow towards dry lakes or minor depressions (WRM 2015).

The Nepean mine is located on a ridge of slightly elevated ground that forms the western boundary of the Box Creek catchment area. Run off in the vicinity of the Nepean mine flows into a dry lake at the eastern toe of the ridge; overflow flows south through the edge of the injection borefield on the eastern side of the project area towards Tin Tin Lake (WRM 2015).

iii Flow

As Box Creek is an ephemeral stream, there is no available streamflow data. Box Creek flow characteristics have been determined based on observations with landholders and are reported in WRM (2015) as follows:

- there was sufficient flow in Box Creek to cause Pitarpunga and Tin Tin lakes to fill and overflow in 1956 with flow originated from flooding in the Lachlan River;
- flooding was observed several times in the 1970s, although it is unclear if this was as severe as the 1956 flood, or if the lakes filled and overflowed; and
- flooding occurred in the project area and surrounds in 2010/2011, however it is thought this was due to heavy, localised rainfall in the Box Creek catchment area rather than overflow from the Lachlan River (via Merrowie and Middle creeks). There was not sufficient volume to cause Tin Tin and Pitarpunga lakes to fill and overflow into Box Creek in the vicinity of the project area.

The 2010/2011 flood event recorded an estimated peak discharge in Box Creek downstream of the Balranald-Ivanhoe Road of 150 m^3/s. This was the result of a two day rainfall event that exceeded 1 in 100 annual exceedance probability (AEP) event (WRM 2015). The AEP is the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year (BoM 2014).

Although not mentioned by landholders, a flood also occurred in 1990 in the Lachlan River detailed in the *Lachlan River – Hillston Floodplain Management Plan Lake Brewster to Whealbah* (WRM 2015). The 1990 flood event in the Lachlan River had an AEP of between 1 in 60 to 1 in 70, and a flow rate of 3,000 ML/day (WRM 2015). This flood did not result in sufficient flows in Box Creek, and Pitarpunga and Tin Tin lakes, despite high flows in Middle and Merrowie creeks. Peak flow rates in the Lachlan River during the 1990 and 1956 flood events were comparable, however the duration of the 1956 event was approximately three months longer (totalling nine months) than the later flood. This suggests that for flooding in the project area to occur, flooding of the Lachlan River in excess of six months is required.

iv Water quality

The Murrumbidgee and Murray rivers in the vicinity of the project area contain fresh water supplies that are frequently used for purposes such as town water supply and irrigation. NOW reports that the recent salinity of the Murrumbidgee River at the Balranald weir is fresh, with an average electrical conductivity (EC) of 0.2 mS/cm (in February 2015). Background water quality data is available for the Lachlan, Murrumbidgee and Murray rivers; however this is not relevant to the Balranald Project as no water will be discharged to these rivers.

14.2.2 Groundwater

i Features

The project area is within the alluvial sediments of the Murray Basin, which is a large closed groundwater basin with regional aquifer systems, confining layers and permeability barriers to groundwater flow. The combined thickness of the Murray Basin sediments ranges from 250 to 290 m.

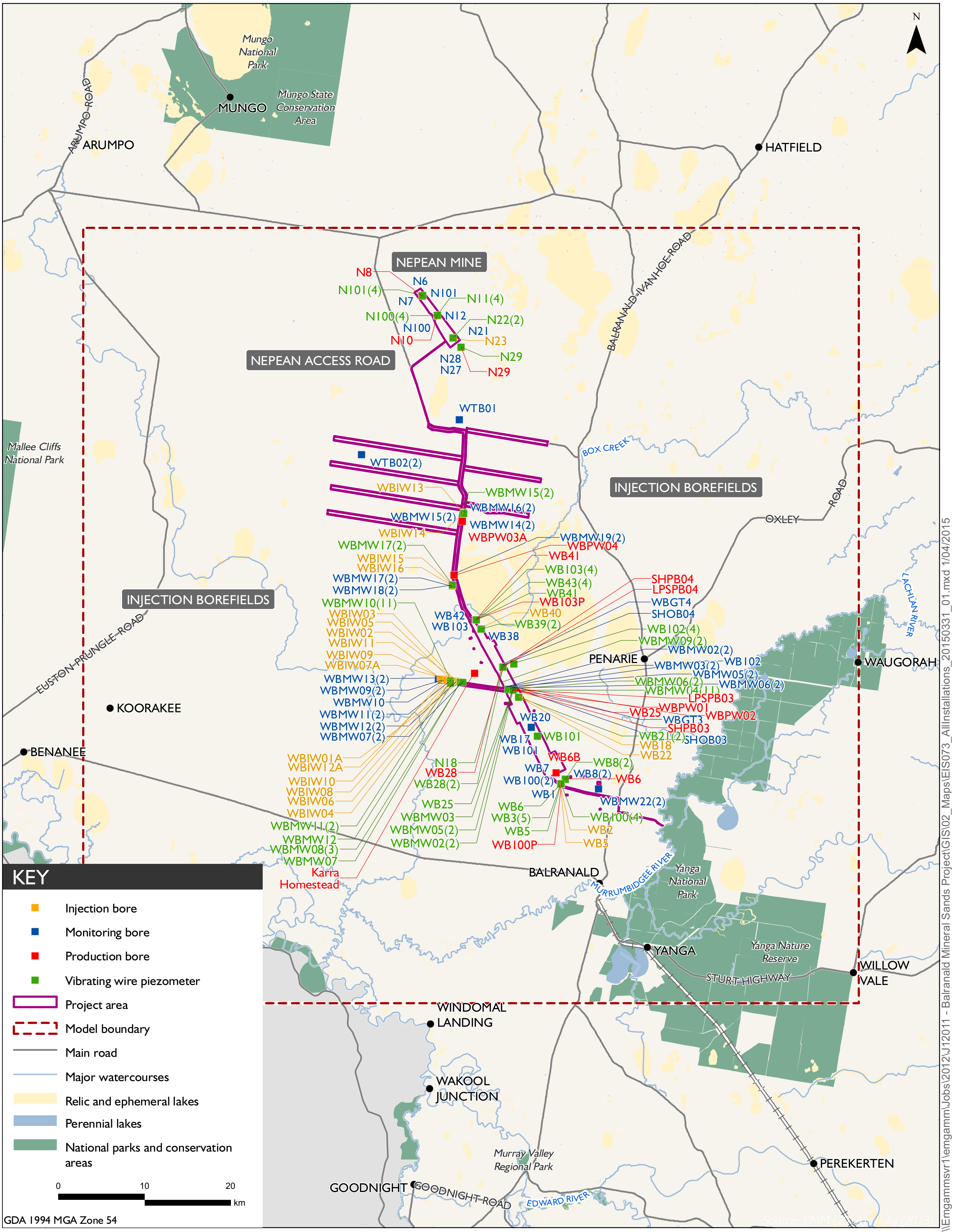
The basal unit overlying the basement rocks (Palaeozoic rocks of the Lachlan Fold Belt) is the Olney Formation, comprising predominantly continental clay, silt and sand sediments (Kellet 1989). A marginal marine unit, the Geera Clay, interfingers through the middle sequence. Overlying the Geera Clay and Olney Formation is the Loxton-Parilla Sands, a thick sequence of marine sands that contains the target mineral deposits. Overlying the Loxton-Parilla Sands is the Shepparton Formation, comprising fluio-lacustrine unconsolidated clays and silts. Each of these formations are described in the following sections.

The geology of the Murray Basin (conceptualised), including the project area, from east to west is shown in Figure 3.1. Iluka's groundwater monitoring installations are shown in Figure 14.1.

ii Formations

a. Shepparton Formation

The Shepparton Formation is a composite aquifer-aquitard system comprising unconsolidated clays, sandy clays and fine grained sand. The Shepparton Formation hosts the superficial water table in most of the project area, although the bulk of the Shepparton Formation at the Nepean deposit is unsaturated. Stiff clay lenses 4-6 m in thickness at the base of the Shepparton Formation separates the groundwater within the Shepparton Formation from the groundwater within the Loxton-Parilla Sands at the West Balranald deposit, however Iluka confirmed clay rich layers are not universally continuous.



Iluka's groundwater monitoring installations

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Figure 14.1

b. Loxton-Parilla Sands

Jacobs (2015) divides the Loxton-Parilla Sands into repeating cycles of a facies stack moving upwards from offshore, to lower shore, to surf zone and then foreshore facies. These different depositional zones have varying hydraulic conductivities. At the West Balranald deposit the surf zone has the highest hydraulic conductivity and can be several meters thick, while the offshore facies, consisting of finer units, are conceptualised as lower permeability layers.

c. Geera Clay

The Geera Clay has a very low permeability and is therefore considered an aquitard. This unit acts as a low permeability barrier to groundwater movement between the Loxton-Parilla Sands and Olney Formation, and has a profound effect on pressure distribution and water chemistry of the Olney Formation.

d. Olney Formation

The Olney Formation is confined where overlain by Geera Clay in the west, however further east, the formation is considered semi-confined (Kellett 1989). Above the Ivanhoe Block, the mid Olney Formation is largely replaced by the Geera Clay and the lower Olney Formation is truncated by the basement rocks (the Iona Ridge).

iii Recharge

Regionally, recharge to the Murray Basin sediments within NSW primarily occurs along the basin margins to the east, with groundwater then flowing generally in a westerly direction. Recharge from these easterly areas is largely via a combination of river leakage (particularly during overbank flood events) and direct rainfall recharge. Localised recharge also occurs across the Murray Basin, particularly adjacent to major rivers and during high flow or flood events.

Locally in the project area there is limited recharge from direct rainfall, with most recharge to the area occurring via throughflow from the east. While minor direct rainfall recharge may occur locally, the low rainfall and high evaporation means this volume would be minimal and the presence of stratified low permeability clays and silts in the Shepparton Formation often results in this water entering perched systems. The Loxton-Parilla Sands and the Olney Formation is recharged via through flow from the east of the project area.

In the Lower Murrumbidgee, the connectivity between the Murrumbidgee River and the underlying Murray Basin sediments is considered to be seasonably variable (MDBA 2012). Locally, the depth to groundwater near the Murrumbidgee and Murray rivers is lower than the river stage, which indicates the loosing nature of these rivers in this local area.

iv Discharge

The central divide between the Murray and Darling basins, overlying the rising basement associated with the Ivanhoe Block, is the regional groundwater discharge zone for the eastern Murray Basin in NSW. The rising basement causes aquifer thinning, and along with the decrease in permeability associated with the Geera Clay, creates the potential for upward vertical discharge (Kellet 1989).

The ancient and dry lakes in the vicinity of the West Balranald deposit (ie Tin Tin, Pitarpunga and Muckee lakes), with relatively lower topography and apparent surface salinisation, form localised groundwater discharge features experiencing evaporative losses from the watertable.

v Levels and flow

There is a general decrease in the depth to water moving north and north-west from the Murray and Murrumbidgee rivers. At the northern end of the West Balranald deposit, and at the Nepean deposit, the groundwater table lies within the Shepparton Formation. At the southern end of the West Balranald deposit the water table lies within the Loxton-Parilla Sands.

Groundwater flow at the project area is generally from east to west. In the deeper Olney Formation, groundwater flows to the west-northwest as a result of the basement structure in this area. The Ivanhoe Block impedes westerly through flow in the Riverine Plain as the regional aquifer either thins out over the rising basement block or is truncated by it. The Geera Clay also forms a hydraulic barrier to lateral flow to the lower Loxton-Parilla Sands and the middle Olney Formation, forcing westerly groundwater flow lines in the middle and upper Olney Formation to converge.

Kellett (1991 and 1994) indicates artesian conditions to the east of the project area and URS (2012) reports a measured head at a monitoring bore at the West Balranald deposit (WB3 P1) of 3.1 m above the ground surface. Iluka has identified two artesian Olney Formation pastoral bores (HD1 and T02) in the vicinity of the West Balranald deposit. A strong vertical upward gradient is pronounced at NOW nested monitoring sites GW036866 (40 km north of Balranald town) and GW036674 (68 km north of Balranald town) where there is approximately 9 m and 5 m difference, respectively, in head pressure between the Loxton-Parilla Sands, and the deeper Geera Clay and Olney Formation. Upward vertical head gradients are consistent with the monitoring sites at the discharge end of the Balranald Tough and near where the basement rises, causing upward groundwater flow.

Comparison of heads in the Shepparton Formation and Loxton-Parilla Sands at NOW nested monitoring site GW036866 demonstrates the potential for a small upward gradient from the Loxton-Parilla Sands to the Shepparton Formation. This would tend to suggest that, away from the rivers, groundwater has the potential to move upwards. If this is the case, rainfall recharge cannot be significant, otherwise a downward gradient would be observed, and it is likely evapotranspiration may be intercepting seepage of rainfall that does penetrate to the water table.

vi Hydraulic conductivity

Hydraulic conductivity in the Shepparton Formation is highly variable, due to the heterogeneous nature of this formation with sand and clay lenses throughout. Continual lateral flow through formations is not common. A range of bulk hydraulic conductivity is observed in the Loxton-Parilla Sands and this is due to the differences in the hydraulic conductivities of the different surf and offshore zones. The stratification in this unit is likely to cause considerable vertical anisotropy in hydraulic conductivity measurements.

vii Hydrogeochemistry

Groundwater quality within the Murray Basin is variable, and Evans and Kellet (1989) report that one-third of the resource is highly saline with salts originating from the marine depositional environment. The cycle of low precipitation and high evaporation is also likely to enhance the salinity within the shallow geological formations. The high occurrence of groundwater abstraction and irrigation in the eastern areas of the Murray Basin has enhanced shallow and mid groundwater interaction, contributed to the mixing of saline waters and has remobilised salts from previously unsaturated zones. Ancient and dry lakes in the western areas are indicative of groundwater discharge zones and the formations are likely associated with saline conditions in the upper aquifers (Kellet 1989).

There is a general trend of salinity concentrations in all water bearing units to increase linearly from east to west, in line with groundwater flow direction. The salinity trend is proportional to distance along a flow line and this indicates mixing between groundwater and additional water inputs via stream leakage and rainfall infiltration. Groundwater mixing influences the water quality and reduces the degree of difference between the water quality of different formations.

Water quality in the Shepparton Formation is highly variable and related to permeability, depth to water table and anthropogenic influences. There are local areas in the Shepparton Formation where pockets of fresher groundwater lenses are identified to be floating on regional saline groundwater. Water quality sampling indicates that the salinity of the Shepparton Formation and Loxton-Parilla Sands is similar, and these formations had the highest EC and total dissolved solids (TDS) measurements (average EC of 48 millisiemens per centimetre (mS/cm) in the Shepparton Formation and average EC of 56 mS/cm in the Loxton-Parilla Sands). The TDS and EC is lower in the Olney Formation, with an average EC of 9.3 mS/cm, and this is comparable to the EC in the Geera Clay.

The EC of sea water is 53-60 mS/cm. An EC between 0 and 0.5 mS/cm is considered to be good drinking water for humans. Beef cattle and adult sheep can tolerate water with an EC up to 6 and 7 mS/cm. Water below 3 mS/cm is generally suitable for irrigation. Water with an EC up to between 5 to 12 mS/cm can be used for irrigation, however this requires consideration of the crop and plant salt tolerance (ANZECC/NRMHC 2011).

As such, water within the Loxton-Parilla Sands (which is similar to sea water) cannot be used for human or stock consumption, or irrigation. Water within the Olney Formation generally can only be used for stock.

14.2.3 High priority groundwater dependent ecosystems

NSW WSPs include schedules with lists of high priority GDEs which are required to be assessed using the minimal impact criteria outlined in the AIP. The applicable groundwater WSPs listed in Chapter 6 were reviewed for reference to GDEs. Only the Lower Murrumbidgee Groundwater WSP identified high potential GDEs. Two high priority GDEs were identified in the area:

- terrestrial vegetation along the floodplains and prior streams, which occur to the south and west of the Murrumbidgee River; and
- the Great Cumbung Swamp, which, as previously discussed, is a known ecological asset, which is about 42 km to the east of the West Balranald mine (see Figure 3.2 and 14.1).

There are no high priority GDEs contained within the Western Murray Porous Rock Groundwater Source within the MDB Porous Rock WSP, in which the project area is located.

i Ecosystems that potentially rely on groundwater

Baseline investigations (SKM 2011) undertaken as part of the PFS identified the occurrence of ecosystems that potentially rely on groundwater in the vicinity of the project area. These investigations mapped and characterised ecosystems that potentially rely on groundwater into two broad categories:

- wetlands and vegetation associated with the Murrumbidgee, Lachlan and Murray river floodplain environments, as per the Lower Murrumbidgee Groundwater WSP for the vegetation to the south and west of the Murrumbidgee River; and
- vegetation (primarily Black Box woodland) outside the floodplain and permanent streams, in topographic depressions where the water table may be shallow enough and not too saline.

The distribution and type of ecosystems that potentially rely on groundwater are shown in Figure 14.2.

Potential groundwater reliance associated with both of these environments is likely to be only partial, if at all. Groundwater use by vegetation in the region is influenced by two main factors: the depth of the water table and salinity. The ecosystems that potentially rely on groundwater associated with the floodplain environments include the high value River Red Gum forests and the Great Cumbung Swamp (which, as discussed previously, has already been identified as a high priority GDE by NOW). While Black Box woodland is generally less significant in terms of its ecological value, it provides locally valuable fauna habitat (as well as shade and shelter for stock) in a landscape sparsely populated by trees.

Rainfall and periodic flooding of the Murrumbidgee River are more likely sources of water for vegetation (URS 2012). Thus floodplain environments are considered to have a low susceptibility to altered groundwater conditions due to the close presence of the Murrumbidgee River, a regular water source. Further from floodplains, vegetation may have a greater reliance on groundwater as there are no permanent water sources in these environments.

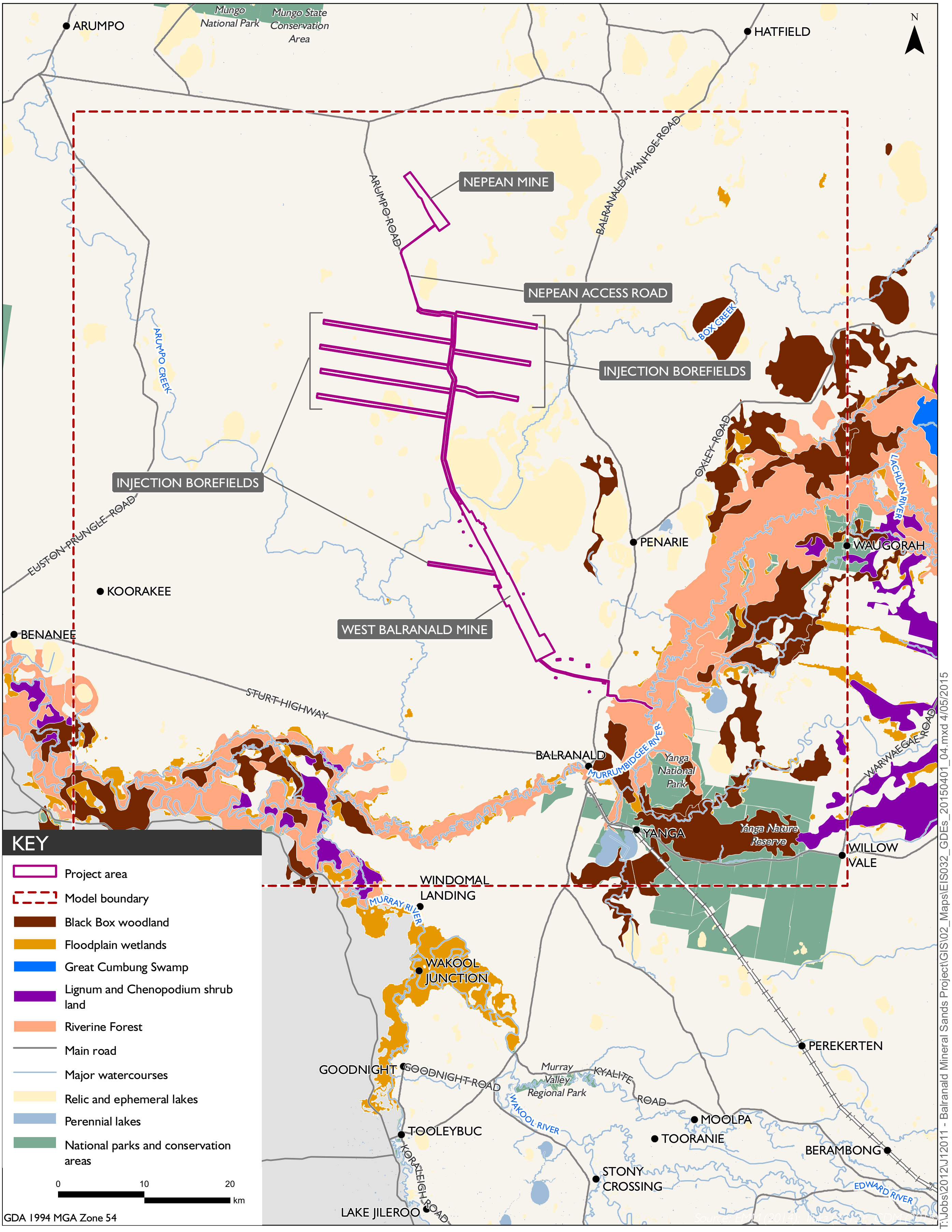
An investigation was undertaken to establish where the Black Box vegetation was accessing water from (Appendix J). This study found that rainfall and episodic surface water (irregular flooding and/or pooling from heavy rainfall) provided the dominant water source for Black Box, although there was some potential for these trees to use groundwater opportunistically to supplement their water needs. Previous studies have shown Black Box to be a hardy, resilient species capable of sustaining droughts and quite saline conditions (up to 60 mS/cm).

14.2.4 Water users

Based on data from NOW, there are 112 privately owned registered bores within a 65 km radius of the project area. Fifty seven are screened in the Shepparton Formation and 35 are screened within the Olney Formation. They are predominantly registered for stock and/or domestic use. The location of the landholder bores and the screened formations is shown in Figure 14.3.

Land and Water Consulting (2014) undertook a groundwater use study within the project area. This comprised interviewing 16 available landholders on the status and use of any bores on their property. The majority of the registered landholder bores in the project area rely on groundwater for predominantly stock use, and bore water is the only source of stock water with the exception of intermittent surface water runoff.

During the bore census artesian conditions were observed in four bores screened in the Olney Formation. Salinity conditions were variable (ranging between 350 mg/L to 5,300 mg/L TDS) and the bores were mostly low yielding, typically around 0.4 L/s.



EMM
ILUKA

GDE distribution

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Figure 14.2

14.2.5 Hydrogeological numerical model

A regional groundwater model (BAL2.0) was developed by Jacobs (2015) to simulate groundwater behaviour under the proposed mining conditions, including dewatering abstraction and reinjection conditions. This was used to inform the design of the dewatering systems and to quantify impacts to the groundwater regime. Local scale 'sub-models' were calibrated to site production and injection trials and this was extrapolated across the full BAL2.0 model domain to calibrate the regional model.

The numerical model is based on extensive site investigations undertaken over a number of years, a compilation of data used to describe the hydrostratigraphy, recharge and discharge features and groundwater flow directions, and a sound conceptual hydrogeological model. The model domain, measuring 90 km east-west and 90 km north-south, includes the West Balranald and Nepean deposits, and part of the Murrumbidgee and Murray rivers.

14.3 Impact assessment

This water assessment examines the following project-related activities: construction and use of site infrastructure, dewatering, water reinjection, mining and on-site water storage and the impacts to water quality, water level and pressure, groundwater surface water interaction and the physical disruption of aquifers and water courses. The receptors that have been identified as potentially being sensitive to water impacts in the region include:

- ecosystems that rely on groundwater, including GDEs;
- Murrumbidgee River and ephemeral water courses; and
- private landholder bores, properties and infrastructure.

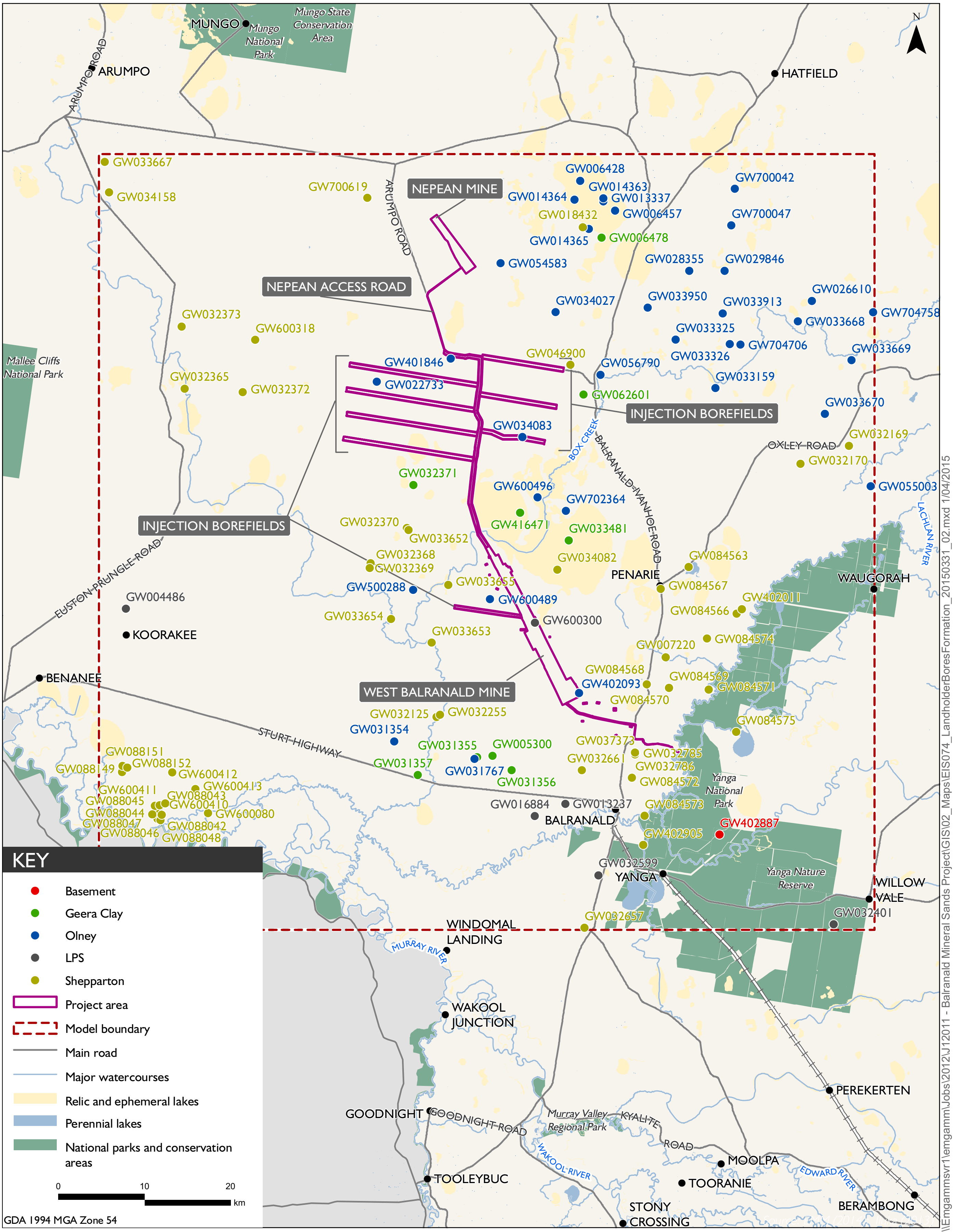
14.3.1 Assessment criteria

The minimal impact thresholds outlined in the AIP will be used to assess the potential impacts to groundwater resulting from the Balranald Project. This is in accordance with the Minister's requirements for approval and administration of the WMA 2000. The AIPs 'minimal impact considerations' are employed to assess impacts to water table levels, water pressure levels and water quality across a range of different groundwater system types.

The groundwater within the Western Murray Groundwater Source in the MDB Porous Rock WSP in the vicinity of the Balranald Project is classified as 'less productive', based on the very high salinity levels. The greater water source is then classified as a 'porous rock' water source. The minimal considerations for porous rock units of less productive groundwater systems have therefore been adopted for this assessment.

14.3.2 Site water management

Site water management including the management of water sources and proposed water management infrastructure is described in Section 4.7.



Landholder bores and formation screened

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Figure 14.3

14.3.3 Water demand

Construction phase water supply will be sourced from the Olney Formation. The volume of abstracted water is 75 ML/yr for the first 1.5 years before mining commences, this volume increases to 150 ML/yr for a further 1 year, when two bores are operational. For the final half year of pre-mining construction the volume reduces back to 75 ML/yr. The total volume taken is 300 ML over three years.

Demands for water during the operation phase would be primarily generated by the processing plant, dust suppression and potable requirements for amenities. The ISP also requires potable water which would be sourced from the water supply pipeline and filtered. The water demands for the Balranald Project are summarised in Table 14.1.

Water balance modelling indicates that the Balranald Project would source the majority of the required water from dewatered groundwater with make-up water supplied via on-site sources (ie rainfall runoff, and groundwater inflow to the pit). Mine affected water will be reused to supply the MUP, processing plant and saline water dust suppression demands. The dewatering borefield production rates are predicted to exceed the net makeup water demands at all stages of mine life.

Table 14.1 Operation phase water demands

Demand	Water type	Average volume (ML/year)	Source
Dust suppression			
Overburden/ore removal	Saline	380	Saline groundwater
Saline overburden rehabilitation			
Mine access road, haul roads, service roads			
Topsoil/subsoil and non-saline overburden removal	Non-saline	310	Water supply pipeline
Soil and non-saline rehabilitation			
Light vehicle roads			
Process water			
Process plant demand (PCP, WCP, WHIMS)	Saline	15,075	Mine affected water Saline groundwater
MUP demand	Saline	4,160	Mine affected water Saline groundwater
ISP demand	Non-saline	100	Water supply pipeline
Wash down bays	Non-saline	10	Water supply pipeline
Workforce consumption			
Personnel – potable	Potable	5	Truck
Personnel – toilet and non-drinking	Non-saline	10	Water supply pipeline
TOTAL DEMAND	*Saline*	*19,615*	Mine affected water Saline groundwater
	Non-saline	*450*	Water supply pipeline
	Potable	*5*	Truck

14.3.4 Site water balance

A water balance combining the mine affected water management system, saline groundwater and reinjection volumes has been prepared for pre-mining, and Years 1, 4 and 8 of the conceptual mine plan. This is presented in Table 14.2 and indicates marginal net change in total site water inventory during operation. A representative water schematic is also shown in Figure 14.4.

Table 14.2 Water balance (average rainfall year)

Parameter	Construction (total*)	Year 1 ML/ yr (operational)	Year 4 ML/yr (operational)	Year 8 ML/yr (operational)
Inflows to water management system				
Groundwater inflow to pit	-	1,577	1,577	0
Catchment runoff	-	34.9	32.5	37.7
Direct rainfall on water storages	-	11.2	12.1	4.8
Dewatering borefield	-	19,532	22,421	1,239
Saline water supply to processing plant	-	-	-	841
Water supply bores – Olney Formation	300			
Total inflows	**300**	**21,155**	**24,043**	**2,123**
Outflows from water management system				
Net site water management system	-	1,558	1,553	27.3
Uncontrolled releases	-	0	0	0
Evaporation	-	68	71	27.7
Reinjection	-	19,532	22,418	2,065
Total outflows	**-**	**21,158**	**24,042**	**2,120**
Net change in total site water inventory	**-300**	**-3**	**1**	**3**

Notes: Taken from Jacobs 2015 and WRM 2015.
** Total water usage has been provided for 2.5 years as the rate of abstraction is variable during this period.*

The water management system maximises the capture and reuse of mine affected water. The volumes of required makeup water are significantly less than the volumes of saline water that are predicted to be produced by dewatering.

14.3.5 Surface water assessment

With the exception of the water supply pipeline from the Murrumbidgee River, there is an absence of permanent surface water sources within the project area. There are no surface water users, and no surface water related infrastructure. Although the Balranald Project is located in the Murray Basin and proximate to the Murrumbidgee, Murray and Lachlan rivers, there are no direct surface water impacts to these rivers.

The potential impacts to the surface water environment resulting from the Balranald Project include:

- loss of catchment area that drains into Box Creek, Pitarpunga and Tin Tin lakes due to capture of run off within on-site storages and the pit;
- potential for runoff from the project area to become contaminated with elevated salinity, low pH, heavy metals, and fuels, oils and grease due to interaction with either:
  - saline groundwater (at West Balranald mine in particular);

- stockpiles, overburden or acid forming materials;
- MUP area and processing areas;
- mine voids;

- overflow of the mine water management system during large rainfall events resulting in the release of sediment laden water or saline groundwater;
- interference with flood flows along Box Creek, Pitarpunga and Tin Tin lakes and their tributaries; and
- depletion of regional water availability associated with abstraction of water from the Murrumbidgee River and potential use from other external sources.

Each of these potential impacts is addressed below.

i Loss of catchment area

During the operational phase of the Balranald Project, the maximum catchment area draining to the mine water management system would be 194.3 ha. This is less than 1% of the total Box Creek catchment area (WRM 2015). The loss of 1% of the catchment area is considered insignificant, especially considering the ephemeral nature of Box Creek and the lack of reliance by environmental and human users on this system.

ii Impacts to receiving environments from potentially contaminated runoff

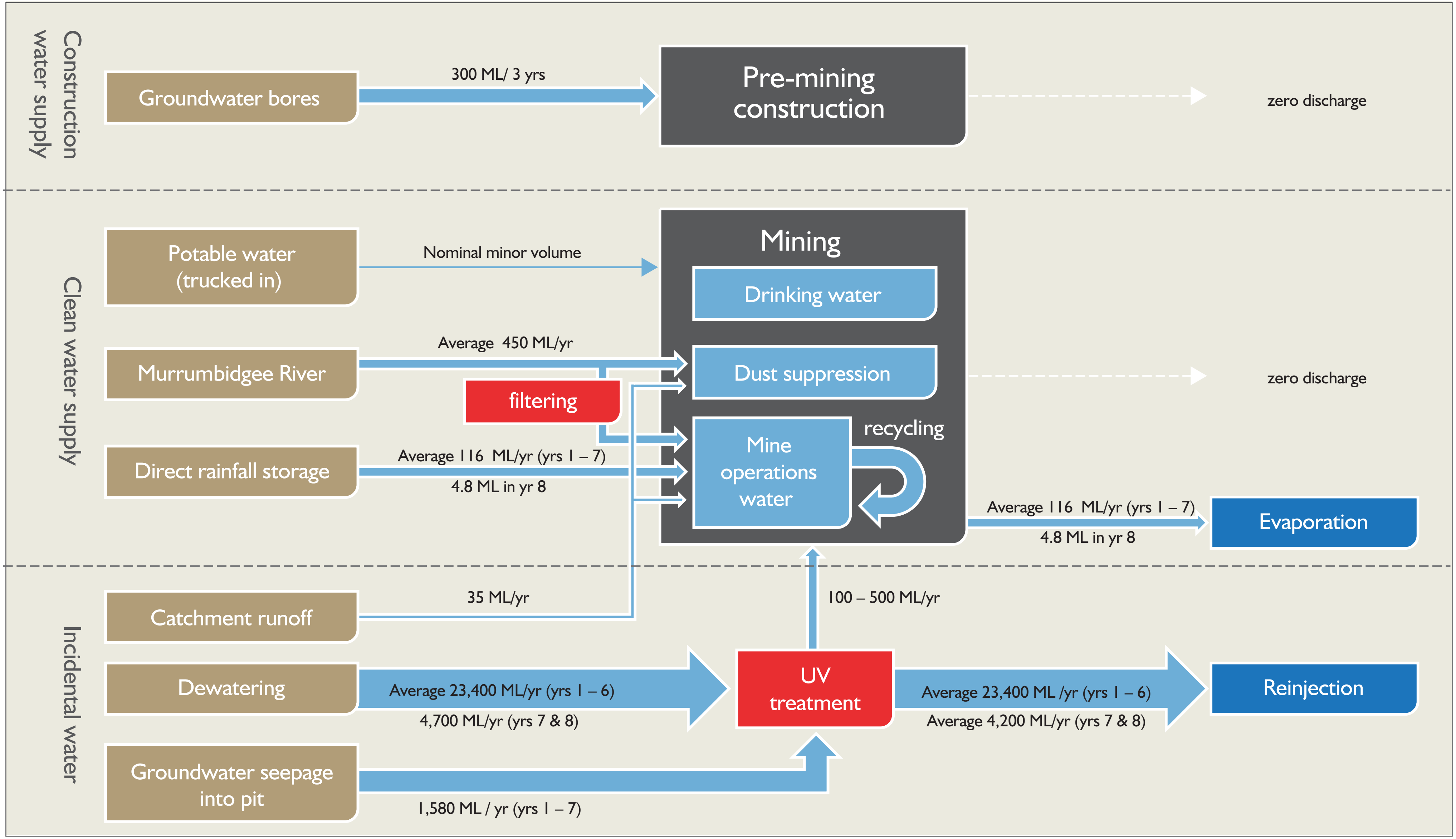
There is the potential for runoff water quality to be affected by chemicals, natural elements or undergo physiochemical changes (ie increased EC or lowered pH), and cause contamination to possible receptors, including groundwater, soils and vegetation. However for this to occur surface water needs to be present and in contact with a contaminating agent, and the surface water then needs come into contact with a receptor. This is considered a highly unlikely scenario due to the lack of surface water in the Balranald Project area and the implementation of a water management plan which will control all project water.

Surface water runoff from undisturbed areas will be diverted, where possible, around areas disturbed by mining and released from the site before it has the potential to become contaminated. Surface water runoff from disturbed areas has the potential to be contaminated, and this water will be captured, stored and treated as part of the mine water management program. No run off from disturbed areas will be released from the site.

In the event of a heavy rainfall event sulfuric acid has the potential to become mobilised, causing acidification of soils, groundwater or process water. In addition acidic seepage from stockpiles could also cause acidified ponding. Appropriate management of stockpiles will greatly reduce the volume of potential acidity generated from stockpiles.

There will be no surface releases of saline groundwater abstracted from dewatering. The majority of the water abstracted will be injected back into the Loxton-Parilla Sands.

If run off is contaminated with chemicals (ie fuels, oils, lubricants) from a spill event it will be treated in accordance with the water management plan.



EMM EMGA Mitchell McLennan

ILUKA

Water balance schematic

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Figure 14.4

iii Mine water overflow

The project area has a dynamic flooding history and historic flooding has resulted in the inundation of the entire Box Creek floodplain. Flooding in Box Creek can be the result of heavy rain fall events in the local catchment area, floodwater overflowing from the Lachlan River and draining into Box Creek via Merrowie and Middle Creek or a combination of the two scenarios.

WRM (2015) simulated flood flow behaviour in Box Creek and its floodplain, including Muckee, Pitarpunga and Tin Tin lakes using TUFLOW hydrodynamic modelling software to investigate the possibility of the West Balranald mine and subsequent final void becoming inundated by floodwater overflowing from Box Creek or the nearby lakes (shown in Figure 14.5). A constant discharge of 300 m^3/s was applied to Box Creek, this discharge was applied to represent a conservative flood event greater than 1 in 100 AEP, and was twice the estimated February 2011 peak discharge in Box Creek prior to entering Pitarpunga and Tin Tin lakes. The Nepean deposit is located outside of the predicted Box Creek and Tin Tin Lake flood extent, although parts of the Nepean access road and injection borefields are located within the flood extent.

Modelling indicates that the West Balranald mine and subsequent void are not predicted to be completely inundated by flooding from Box Creek, while parts of the Nepean access roads and the reinjection borefields may be subject to inundation. Parts of the West Balranald mine could be potentially inundated by floodwater that backs up into the Muckee Lake from Pitarpunga Lake. The greatest inundation (6.5 m) is expected at Muckee Lake adjacent to West Balranald mine, although at Pitarpunga Lake, also adjacent to West Balranald mine, the height of the maximum possible inundation is only 0.36 m. The flooded area coincides with the limits of the alluvium located in low lying areas.

WRM (2015) concludes there is a less than a 1% chance of uncontrolled release of mine affected water during Year 1 and 4. All predicted uncontrolled releases of water from mine affected water storages simulated in the modelling were associated with the same rainfall event (February 2011), which had some 72-hour rainfall intensities that were 34% greater than estimated 1 in 100 AEP rainfalls. If a rainfall event of this nature occurred, the predicted volume of uncontrolled releases would be small and diluted with large amounts of clean runoff. No uncontrolled releases of mine affected water are predicted for Year 8, due to the volume and configuration of the mine water.

iv Interference with flooding

The majority of the mine infrastructure for both the West Balranald and Nepean mines is located outside the predicted Box Creek and associated lakes flood extent area. Mine infrastructure located in areas subject to flooding, including a small part of the West Balranald mine, and parts of the Nepean access road and injection borefield, are not expected to impact on flooding. The access road will be constructed at the existing ground level and is not expected to impact predicted flood levels, velocities or flow distributions. The injection bores have a small diameter and likely present an insignificant obstruction to any flood flows, and these bores would not be damaged by flood flows. A small bund wall would be sufficient to protect the West Balranald mine from flooding, if required.

v Regional surface water availability

The use of external water will be minimised by sourcing all processing water from the mine water management system and saline water extracted from the dewatering borefield. No external water will be required to supply these demands, and hence these demands will have no impact on regional water availability.

The required water access license to take water from the Murrumbidgee River will be purchased from the registered water license market under the Murrumbidgee River WSP. The only source of external water will be potable drinking water trucked into the project area.

14.3.6 Groundwater assessment

A groundwater assessment was prepared which considered changes to groundwater levels, groundwater chemistry and hydrogeology in respect of private landholder bores, GDEs, hydrostratigraphy and geochemistry.

i Groundwater levels

The abstraction and injection of groundwater will result in changes to the pre mining groundwater levels and potentiometric pressures. A numerical model was prepared which predicted changes in groundwater levels as a result of the Balranald Project generally across the project area and locally at identified sensitive receptors.

a. Construction phase abstraction

The numerical model concluded that abstraction from the Olney Formation for construction purposes resulted in localised drawdown, with the 0.2 m drawdown contour constrained to a small area (ie less than 10 m) at the Plant Well. Residual drawdown from the two other wells modelled (Wellfield 3 and Wellfield 7), was less than 0.2 m.

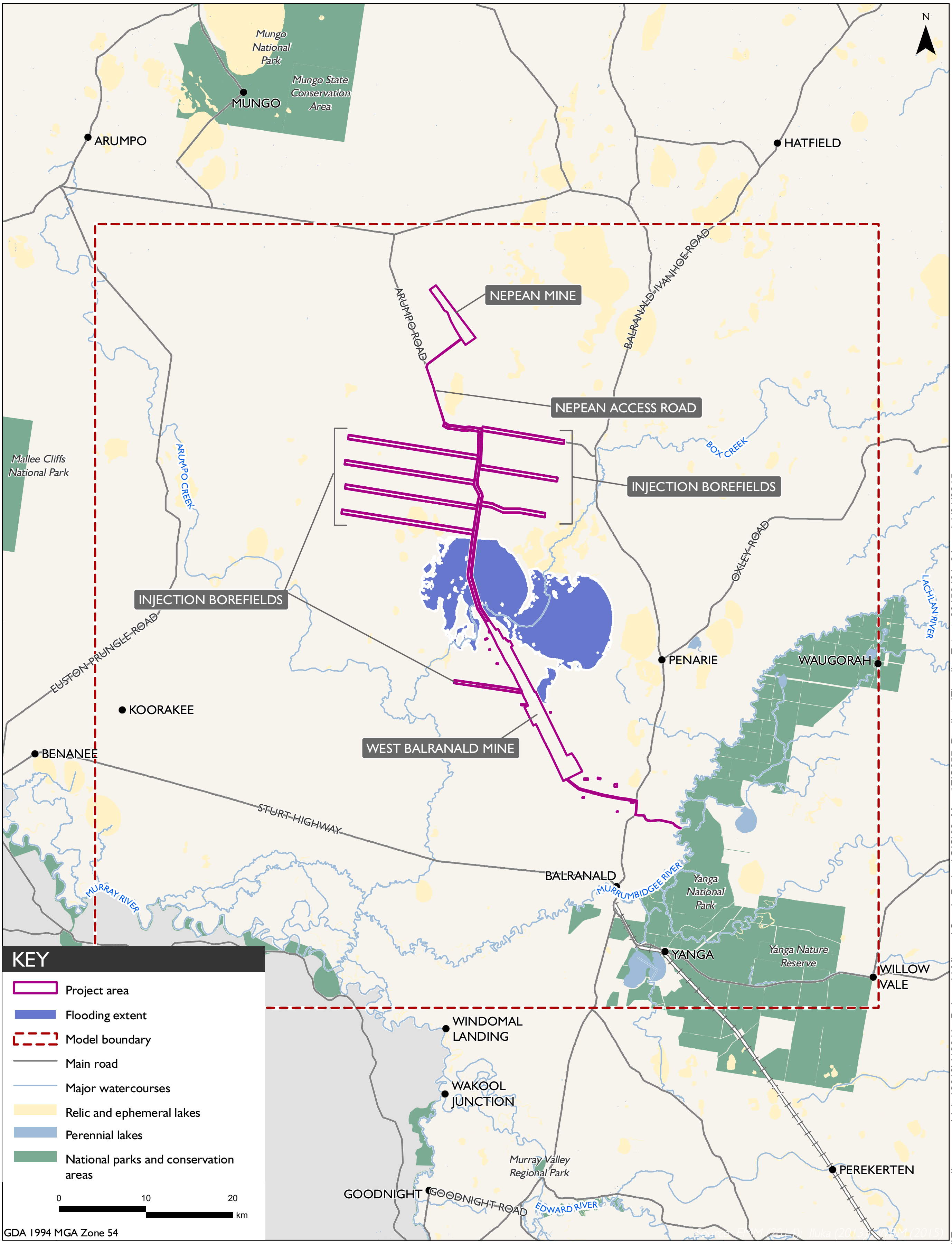
The relatively minor drawdown associated with construction abstraction over this short three year period will not cause any impacts of concern and is not explored further as a potential impact.

b. Mine dewatering and reinjection

Dewatering from the Loxton-Parilla Sands will result in a decrease in the potentiometric pressure in this formation, and to a lesser degree the overlying Shepparton Formation. The numerical model predicts an average dewatering rate at the West Balranald mine of 746 L/s for the six years of mining and an average of 95 L/s during the two years of backfilling, totalling 145,109 ML over 8 years. The model predicted average dewatering rate at the Nepean mine is 100 L/s for the 1.5 years of mining, comprising a total of 4,671 ML (Jacobs 2015; Appendix I). Dewatering aims to maintain the potentiometric surface of the Loxton-Parilla Sands at a depth 5 m below the pit floor.

Drawdown cones, representing reductions in potentiometric pressures, at the West Balranald mine extend in the Loxton-Parilla Sands and Shepparton Formation for the length of the deposit during mining. The extent of the 2 m drawdown cone extends approximately 5 km in the Loxton-Parilla Sands from the mining area at its maximum extent. The 0.2 m drawdown cones continue to spread laterally (by up to 15 km in the Loxton-Parilla Sands and 10 km in the Shepparton Formation) during the 100 year duration when post mining conditions are modelled. Drawdown in the Loxton-Parilla Sands as a result of dewatering will increase the vertical hydraulic gradient with the Shepparton Formation, but actual flow between these units is governed by the presence, thickness and continuity of clay layers within the Shepparton Formation.

The model predicted 0.2 m drawdown in the Shepparton Formation and Loxton-Parilla Sands at the end of mining the Nepean deposit (mining year 7.5) is localised, extending no more than 2 km from the deposit in both units. No residual impact of dewatering (ie drawdown) is evident at the Nepean deposit 100 year after mining has commenced.



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Predicted flooding extent

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Figure 14.5

Iluka will inject water produced from dewatering operations back into the Loxton-Parilla Sands. Injection rates peak at around 1,300 L/s during mining and the total modelled injected volume (148,820 ML) is comparable to the volume of abstracted groundwater.

Modelled predicted mounding (ie increase in potentiometric pressures) is observed in the target Loxton-Parilla Sands and overlying Shepparton Formation at the injection borefield. Pressure heads in the Loxton Parilla Sands increase by more than 5 m above the pre-mining pressures, while heads in the Shepparton increase by 2 m. During the 100 years of post mining numerical modelling in both the Loxton-Parilla Sands and Shepparton Formation indicates that the 0.2 m mounding contours continue to expand (to approximately 12 km from the edge of the injection borefields) and a 1 m mounding contour remains at the centre of the borefields. Injection into the Loxton-Parilla Sands will increase the vertical hydraulic gradient with the Shepparton Formation, but upward flow is governed by the presence, thickness and continuity of clay layers within the Shepparton Formation.

During injection, injection will be managed so that the pressure in the Loxton-Parilla Sands is less than 3 m below either natural the surface or the surface of the pit floor at all times. The threshold is a compromise between the unsaturated zone thickness (which is minimal at some locations), the off-path injection bore field footprint and the risk of preferential flow through the more permeable part of the Shepparton Formation. This is a conservative approach and even where clay lens that act as aquitards were absent across the project area, the water table rise is within 3 m of the site surface.

c. Impacts to private landholder bores

Groundwater level fluctuations at private bore locations were predicted using the numerical model (Jacobs 2015). The predictions were made for the entire modelling period, ie during mining and for 100 years of recovery. Table 14.3 provides a summary of the predicted levels of change.

Table 14.3 Overview of predicted groundwater level changes in private landholder bores

Formation	Number of private bores	Maximum pressure mounding (m)	Maximum pressure drawdown (m)
Shepparton	57	0.55	1.63
Loxton-Parilla Sands 1 (upper)	2	0	0.0
Loxton-Parilla Sands 2 (lower)	8	0.02	0.06
Geera Clay	9	0.40	0.39
Olney	35	0.04	0.07

The greatest change in groundwater level is observed as mounding in the Shepparton Formation (1.63 m), which is observed at GW034082, ~6 km east of the West Balranald deposit. There is one location, GW600300, where the observed drawdown is approximately 59.5 m, however this bore is located within the West Balranald deposit and will be decommissioned as part of the mining works. Gw600300 has subsequently not been included in Table 14.3, the overview of predicted groundwater level change.

This assessment indicates that there are no instances where the maximum change in pre mining groundwater level exceeds 2 m. Therefore there is no requirement for 'make good' provisions in accordance with the AIP.

d. Groundwater dependent ecosystems

The Lower Murrumbidgee Groundwater WSP identified two high potential GDEs, the Great Cumbung Swamp and terrestrial vegetation along the Lower Murrumbidgee floodplains and prior streams. Neither of these GDE are vulnerable to project-related impacts due to the distance of these ecosystems from the project area, and the zones of drawdown and mounding. The Great Cumbung Swamp is also hydraulically upgradient from the project area.

Supporting documentation for the Lower Murrumbidgee Groundwater WSP speculates that the groundwater dependence of the terrestrial vegetation along the floodplains and prior streams is minimal, noting they are dependent mainly on surface water flows (CDM Smith 2015). Thus these ecosystems are considered to be ecosystems that rely on groundwater. Potential impacts to ecosystems that rely on groundwater are discussed in the following section.

e. Ecosystems that rely on groundwater

An assessment of the ecosystems that rely on groundwater was undertaken by CDM Smith (2015). This assessment concluded the predicted drawdown impacts are constrained to areas of Black Box vegetation near the West Balranald mine, but the extent of drawdown is such that predicted impacts are rated as low (ie there will be no significant change in distribution). Predicted mounding impacts are constrained to areas of Black Box vegetation near the dedicated injection borefield. A moderate rating was assigned to some areas of Black Box vegetation in this area and there could be some evidence of changing distribution of species and disturbance.

ii Groundwater quality

Modelling undertaken by Jacobs (2015) indicates drawdown and mounding in both the Loxton-Parilla Sands and the Shepparton Formation. Groundwater abstraction and injection will therefore enhance both vertical and horizontal hydraulic gradients. There is potential for localised groundwater mixing and exchange between the Loxton-Parilla Sands and the Shepparton Formation. Vertical groundwater flow however, is dependent on the nature of clay aquitards within the Shepparton Formation and is likely to be localised.

The abstracted groundwater will be predominantly Loxton-Parilla Sands but will also contain groundwater from the Shepparton Formation. The receiving environment is primarily the Loxton-Parilla Sands, but where vertical flow occurs this will also include the Shepparton Formation (but this will be to a much lesser degree).

Assessment of the pre mining groundwater quality data for both the Loxton-Parilla Sands and the Shepparton Formation indicates similar conditions. Specifically, the Loxton-Parilla Sands is of slightly poorer water quality with a higher EC (average of 56 mS/cm in the Loxton-Parilla Sands and average of 48 mS/cm in the Shepparton Formation). The major cations and anions are the same (Na-Cl) in the Shepparton Formation and Loxton-Parilla Sands, although magnesium is also dominant in the Shepparton Formation.

Preliminary assessment of the project site water quality suggests there will be no negative change in the water quality receiving environments. Ultra violet treatment of injected water will reduce the possibility of introducing bacteria.

The beneficial use of the groundwater systems is governed by the very high salinity of the Shepparton Formation and Loxton-Parilla Sands, and this water is unsuitable for the following beneficial uses: human drinking water, livestock drinking water and irrigation (ANZECC/ARMCAZ 2000 and NHMRC 2011). The only beneficial use of this water is therefore considered to be for emergency supply for stock, and for industrial and mining purposes where use of poor quality water is not a constraint.

In accordance with the AIP, there will not be any change to the water quality that would change the beneficial use category of the water in either the Loxton Parilla Sands or the Shepparton Formation as a direct result of the Balranald Project.

iii Mine void

Iluka has identified that the final elevation of the West Balranald pit void (at the northern end of the deposit) will be 52 m AHD based on backfilling. The pre mining measured water level in the Shepparton Formation at the void is ~48.5 m AHD, and the potentiometric surface of the Loxton-Parilla Sands is ~49 m AHD.

Backfilling will provide a fill cover of at least 3 m above the pre-mining potentiometric surface and 3.5 m above the pre-mining water table elevation. The pre mining potentiometric surfaces are also likely to be conservative (ie higher) compared to the expected water levels post mining due to the sediment pile stratigraphy being replaced with more homogeneous backfill, with potentially larger porosity.

The modelled groundwater level drawdown at the mine void is between 1.2 m lower than the pre-mining water level after 100 years of recovery (ie post mining). Therefore the depth to water at the final West Balranald void will more likely be 4.7 m below ground level 100 years after mining. Recovery to pre-mining water level is expected at approximately 110 years after mining.

Given the planned final backfill level is approximately 13 m below the initial and surrounding ground surface elevation of approximately 65 m AHD, any rainfall runoff is likely to collect within the remaining depression. This is likely to lead to increased recharge to the water table below the remaining depression and, therefore, slight mounding of the water table at this point. Given the void will overlie an area of reduced groundwater levels this enhanced recharge will assist with the overall predicted timeframe for recovery of groundwater levels in the area.

The maximum volume of water predicated to accumulate in the West Balranald final void is 34 ML (WRM 2015). The final void is predicted to behave in a similar hydrologic manner to the nearby dry lakes and surface depressions. The small volume of runoff expected to collect in the void will either evaporate or will infiltrate through the floor of the void into the Loxton Parilla Sands. WRM note that between a 1 in 50 and 1 in 100 rainfall event (with ongoing rainfall) the final void would take approximately 5.5 weeks to completely dry out. Under average rainfall conditions the final void would take approximately 2 weeks to dry out.

Although the daily evaporation exceeds the adopted infiltration rate the height of capillary rise in unconsolidated units occurs at depths of less than 0.75 m (which is the most conservative measurement for unconsolidated sediments) (Fetter 1994). Therefore there is enough cover to avoid the creation of an artificial salina, ie an accumulation of salts via evaporation. The maximum EC of water in the final void is not expected to exceed the existing average EC conditions for the Loxton-Parilla Sands (56 mS/cm).

iv Geochemistry

Earth Systems undertook a geochemistry assessment for the Balranald Project in 2015 (Appendix Q). The dewatering and excavation of the deposits will expose sulfidic materials within the ore, overburden, pit wall sediments and process water streams to atmospheric oxygen. This can result in sulfide oxidation and the subsequent generation of acid and metalliferous drainage. The oxidation of sulfide mineral within mine materials is governed by the availability and flux of oxygen, a requirement of oxidation. Grain size, compaction, moisture content and the surface area to volume ratio will affect the degree of oxygen diffusion. Therefore, the overall oxidation of the dewatered sulfide minerals within the pit walls and the ore stockpiles is limited by the diffusion of oxygen into the pit walls and stockpiles via the exposed face (Earth Systems 2015).

The Nepean deposit does not contain significant quantities of sulfidic minerals and is classified as non acid forming. In addition the Nepean deposit is closer to the surface and considerably smaller than the West Balranald deposit and therefore, the extent of disturbance and duration of mining at Nepean will be less than at West Balranald. The Nepean deposit is therefore likely to represent a lower acid and metalliferous drainage risk than the West Balranald deposit.

The West Balranald non saline overburden and saline overburden is also classified as non-acid forming (Earth Systems 2015), while the majority of the organic overburden and ore samples analysed had a low to moderate potentially acid forming classification. There is a pronounced increase in the risk profile of the acid and metalliferous drainage risk classification, with the top of the organic overburden materials defining the upper boundary of the potentially acid forming materials.

Dewatering of the West Balranald deposit will result in the desaturation of large volumes of in-situ organic overburden within the pit walls. This will expose susceptible sulfides, mainly in the ore and organic overburden, to oxidation with the subsequent risk of acid and metalliferous drainage generation. Should heavy rainfall occur, acid and metalliferous drainage could be transported below the pit floor to the natural groundwater level, causing acidification of groundwater. The organic overburden within mining and backfill lags, and the pit walls represents with largest acid and metalliferous drainage risk area (Earth Systems 2015).

Lime dosing may be undertaken to neutralise acid and metalliferous drainage generation, this will raise the pH of the overburden and pit walls. It is expected that the overburden and pit walls will remain predominantly dry during mining, however there is the potential for enhanced alkaline conditions to be mobilised via groundwater flow once the pits are backfilled if there is a low groundwater buffering capacity. Modelling indicates that drawdown curves continue to expand during the 100 years post mining indicating that groundwater will flow towards the centre of the pit voids, and will not contribute to the wide scale mobilisation of alkaline conditions.

v Hydrostratigraphy

The mining and backfilling process will result in localised alteration to the physical structure and distribution (ie stratigraphy) of the Loxton-Parilla Sands and Shepparton Formation. On a regional scale the current hydrostratigraphy and associated aquifer properties are not expected to change. While backfill will be compacted to some degree this will not be undertaken with the specific aim of replicating pre-mining porosity and specific yield properties. The resulting localised porosity and associated specific yield of backfill material is expected to be elevated from current levels.

Along the mine paths, where the degree of stratification is reduced by the mining and backfilling process, it is expected that post-mining hydraulic conductivity will differ from current conditions. Generally, it is expected that, due to the reduction in stratification, vertical hydraulic conductivity will increase while the mixing of higher and lower conductivity material could potentially reduce localised horizontal hydraulic conductivity. Under such conditions localised perched water tables are less likely to occur with recharge more readily percolating down to the regional water table.

14.3.7 Cumulative impacts

There are a number of mining tenements for mineral sand deposits in the Murray Basin in NSW. One of these is the Cristal Mining Atlas-Campaspe Project, which received development consent under the EP&A Act in 2014. The Atlas-Campaspe Project is approximately 20 km to the north of the Nepean deposit and will comprise the extraction of mineral sands from the Loxton-Parilla Sands. Groundwater abstraction would be undertaken to supply mine water and for localised dewatering; this water falls under the Western Murray Porous Rock Groundwater Source in the MDB Porous Rock WSP.

The predicted 1 m drawdown cone extends a maximum 2 km from the southernmost part of the Atlas-Campaspe deposit (which is closest to the Nepean deposit), which does not overlap with the drawdown from the Nepean deposit (Resource Strategies 2013). There is approximately 17 km between the predicted 1 m drawdown cones of the two mines. Cristal Mining currently holds a combined total of 21,442 share components (units or million litres) in the Western Murray Porous Rock Groundwater Source for the Ginkgo and Snapper Mines.

The very poor quality of the groundwater in the Western Murray Porous Rock Groundwater Source limits the beneficial use of the water in the system, and this is represented by the dominant purpose of water being for mining and industrial purposes, and for stock supplies. There is no significant demand for water from this source in the region.

There are also a few operational gypsum projects to the north of the Murray River, including a mine located immediately to the east of the West Balranald deposit; these projects comprise shallow works that do not comprise groundwater abstraction. Therefore gypsum operations are unlikely to contribute to cumulative hydrogeological impacts.

14.4 Management and mitigation

14.4.1 Water management system

Water management for the Balranald Project combines surface water management and the management of abstracted and injected groundwater. The operation of the water management system will be documented in a water management plan which will also contain details on monitoring. A key to successful water management for this project will be the separation and control of water from different sources, and of different water qualities. The water management system will be designed to:

- segregate different water sources and different water qualities (ie mine affected water, and raw water from the Murrumbidgee River, sediment-laden water);
- capture and contain mine affected water and prevent discharge to receiving water environments;
- ensure unused abstracted, saline groundwater is contained and injected rather than discharged to the surface;

- capture and segregate runoff from the following locations:
  - MUP area, processing area, and the saline overburden stockpiles;
  - the non-saline overburden, topsoil and subsoil stockpiles;
  - other disturbed areas;
- divert clean runoff away from areas disturbed by mining activities to minimise the volume of mine affected water;
- manage sediment laden water in accordance with an erosion and sediment control plan that would be part of the water management plan, which will include the capture and treatment of sediment laden water in sediment dams;
- reuse and recycle water in mining operations;
- include contingency measures to accommodate either a surplus or deficit of site water; and
- communicate with key stakeholders (ie NOW, landholders, other users).

The risk of acid and metalliferous drainage requires the management of stockpiles, and exposed (desaturated) organic overburden and ore material. While some residual acid and metalliferous drainage from the in-situ and backfilled organic overburden is likely to be unavoidable, alkaline amendments and specific materials handling practices can lower the overall acid volume generated.

14.4.2 Surface water

The water management plan would include the following surface water mitigation and management measures:

- surface water quality sampling from key storages within the mine affect water management system would be completed, with monitoring parameters based on the expected water quality, and frequency of monitoring based on climatic conditions;
- regular inspection of surface drainage and dam infrastructure; and
- metering and quality monitoring of all water volumes pumped from in pit sumps.

14.4.3 Groundwater

Groundwater quality and groundwater level monitoring has been carried out on the existing network of monitoring bores on an intermittent basis since their installation and quarterly since 2013 for the purpose of baseline data collection. The established monitoring network will be used for ongoing monitoring during construction and operation to assess groundwater level and quality trends; this data will be used to verify the model predictions and assess the degree of inter-aquifer mixing. Groundwater quality monitoring will enable early detection of any change in groundwater quality or possible groundwater contamination.

Field based physiochemical water quality monitoring of the dewatered groundwater prior to reinjection will occur on a daily basis. Real time metering of all dewatering and reinjection volumes will be recorded using telemetry systems. This monitoring data will also be used to record take and injection volumes.

The water management plan will contain all of the details for the groundwater monitoring program and will also include the establishment of groundwater level and quality triggers, actions and contingencies that will be implemented in the event that monitoring indicates an impact. Triggers specific to groundwater reliant ecosystems will also be developed, these will be designed to indicate substantial deviation from expected or predicted impacts or to provide an early warning of an impact that has not been predicted.

14.5 Conclusion

A water assessment was undertaken in accordance with the SEARs. Water investigations, focusing on the hydrogeological regime, have spanned three years and comprise the collection of site data and the development of a numerical model. Both the conceptual and numerical models were constructed using available hydrogeological data including borehole logs, water level and quality monitoring data, regional hydrogeological maps, topography data and published literature, and in accordance with the Australian Groundwater Modelling Guidelines.

The receptors identified as potentially being sensitive to water impacts in the region included:

- ecosystems that rely on groundwater, including GDEs;
- Murrumbidgee River and ephemeral water courses; and
- private landholder bores, properties and infrastructure.

Based on the assessment criteria contained in the AIP impacts from groundwater abstraction and reinjection are likely to be minimal. Overall there are few water related impacts as a result of the Balranald Project due to:

- groundwater quality of the target units for abstraction and injection (Loxton-Parilla Sands and Shepparton Formation) already being highly saline, and not suitable for beneficial uses (human drinking water, livestock drinking water and irrigation) without treatment;
- the absence of landholder bores in areas where 2 m or greater drawdown or mounding is predicted;
- the absence of GDEs; and
- compliance with the Water Act and WM Act, and the rules within the relevant WSPs.

In regards to criteria not included in the AIP the following impacts are possible:

- Predicted mounding impacts which are constrained to areas of Black Box vegetation near the dedicated injection borefield. There could be some evidence of changing distribution of species and disturbance.
- Localised alteration to the physical structure and distribution (ie stratigraphy) of the Loxton-Parilla Sands and Shepparton Formation. Along the mine paths it is expected that post-mining hydraulic conductivity will differ from current conditions.

- Generation of acid and metalliferous mine drainage associated with the desaturation of mine pit walls and overburden, and oxidation of sulfides.

Preliminary assessment of the project site water quality suggests there will be no negative change in the water quality receiving environments. In addition the proposed mine site water management strategy and infrastructure will be designed to ensure that the Balranald Project has a negligible impact on the quality of surface runoff.

15 Soil resources

15.1 Introduction

The SEARs require an assessment of potential impacts on land resources due to the Balranald Project, including:

> an assessment of the likely impacts of the development on the soils, land capability, and landforms (topography) of the site; and
>
> an assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of State Environmental Planning Policy (Mining Petroleum Production and Extractive Industries) 2007;

A soils resource assessment for the Balranald Project was prepared by EMM (Appendix L) which addresses soils, land capability, landforms and topography. The results are summarised in this chapter. An assessment of the compatibility of the Balranald Project with other proximate land uses, including agriculture, in accordance with clause 12 of the Mining SEPP is provided in Chapters 6 and 17.

The soils resource assessment primarily relates to the West Balranald and Nepean mine areas within the project area. These areas are where the greatest level of soil disturbance would occur as a result of mining.

The soils resource assessment was undertaken in accordance with the following regulations, methods and guidelines:

- *Guidelines for Surveying Soil and Land Resources* (NCST 2008);
- *Australian Soil and Land Survey Field Handbook* (NCST 2009);
- *The Australian Soil Classification System* (Isbell 2002);
- *Soil data entry handbook* (DLWC 2001);
- *Agricultural Impact Assessment Guidelines 2012* (DP&I) and *Agfact AC25: Agricultural Land Classification* (NSW Agriculture);
- *Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land* (NSW Government 2013) (BSAL interim protocol); and
- *The land and soil capability assessment scheme: second approximation* (OEH 2012).

15.2 Existing environment

15.2.1 Soil landscapes

Three soil landscapes are identified as occurring in the Balranald area. These landscapes and the associated project area land systems are detailed in Table 15.1.

Table 15.1 Soil landscapes of the Balranald area[1] and associated land systems in the project area

Soil landscape	Description	Associated land systems in the project area
Plains of calcareous earths	Extensive areas of grey-brown loamy calcareous earths, often with exposed cemented carbonate at the surface, to the north of Balranald and between Balranald and Euston; isolated sandy dunes of low relief are associated with flats of various duplex soils; calcareous earths, transitional hard red and yellow duplex soils and areas of grey cracking clays to the east of Balranald.	Arumpo, Condoulpe, Hatfield, Marma
Dunefields of calcareous and brownish sands	Linear dunes of deep brownish sands in association with calcareous sands to the west and northwest of the Balranald, supporting Mallee vegetation; plains and swales of brown calcareous earths and assorted duplex soils associated with the dunes.	Arumpo, Bulgamurra, Condoulpe, Hatfield
Plains of grey cracking clays	Self-mulching grey and yellow-grey cracking clays associated with the rivers and floodplains; mosaic of grey cracking clays and hard duplex soils (red-brown earths) east of Balranald; the remains of prior streams have typically scalded margins and levees, and beds of shallow, calcareous sands south-east of Balranald. Bordering dunes are composed of deep, calcareous and siliceous sands; lunettes and rises consist of yellow duplex soils and granulated clays.	Marma, Rata, Youhl

Notes: 1.From Eldridge (1985).

15.2.2 Land systems

Ten land systems corresponding with the above soil landscapes occur in the project area. The most extensive land system at the West Balranald mine is the Rata land system (28.0% or approximately 2,561 ha). Arumpo is the most extensive land system at the Nepean mine (9.09% or approximately 773.2 ha). The total areas of these land systems within the project area are given in Table 15.2.

Table 15.2 Land systems and extent in the project area

Land system	Area (ha)	Percentage of total (%)
Arumpo	773.2	7.8
Bulgamurra	2.0	0.0
Condoulpe	2,058.4	20.6
Gulthul	1967.7	19.7
Hatfield	975.8	9.8
Marma	1,263.4	12.7
Riverland	17.8	0.2
Rata	2,561.1	25.7
Wilkurra	75.3	0.8
Youhl	274.2	2.8
Total	**9,968.9**	**100[1]**

Notes: 1 -Total = 100.1% due to rounding.

15.2.3 Soil survey

A qualitative soil survey was undertaken in 2013 (GSSE 2013) covering the project area at a maximum scale of 1:50,000. An additional detailed field survey of approximately 4,000 ha of the project area, primarily within the West Balranald and Nepean mine areas, was undertaken in June and July 2014. Soil sampling and subsequent mapping was undertaken at a scale of 1:25,000 in accordance with the *Guidelines for Surveying Soil and Land Resources* NCST (2008).

The soil survey identified six main soil types (or orders) at the West Balranald mine corresponding with 12 soil colour variations (sub-orders). This is consistent with the significant transition in landscape and vegetation from south to north within the project area. The soil types identified comprise:

- Calcarosols (Hypocalcic and Hypercalcic);
- Chromosols (Red and Brown);
- Dermosols (Red);
- Kandosols (Red and Brown);
- Sodosols (Red, Brown and Grey); and
- Vertosols (Brown and Grey).

The Nepean mine was found to be more homogenous with only three soil types and three variants identified comprising Calcarosols (Hypercalcic), Dermosols (Brown) and Kandosols (Red).

Hypercalcic Calcarosols is the most common soil type at both the West Balranald (48.9%) and Nepean mines (75.4%). Brown Sodosols (21.4%) and Red Kandosols (22.8%) are the second most common soil types at the West Balranald and Nepean mine areas, respectively. Red Dermosols (0.2%) and Grey Vertosols (0.04%) are the least extensive soil types found across the mine areas (see Table 15.3).

Table 15.3 Great soil groups, land systems, soil types and areas

Great Soil Groups associated with ASC* order[1]	Land systems[2]	ASC order (Soil type)	ASC sub-order (Variant)	Area mapped within project boundary[3]	
				(ha)	(%)
West Balranald mine area					
Solonised brown soils, grey-brown and red calcareous soils	Rata	Calcarosol	Hypocalcic	51.3[4]	1.72
	Condoulpe, Hatfield, Rata		Hypercalcic	1,463.7	48.9
Non-calcic brown soils, some red-brown earths and a range of podzolic soils	Condoulpe, Hatfield	Chromosol	Red	87.1	2.92
			Brown	85.9	2.88
Prairie soils, chocolate soils, some red and yellow podzolic soils	Rata	Dermosol	Red	6.1[5]	0.2
Red, yellow and grey earths, calcareous red earths	Condoulpe, Hatfield	Kandosol	Red	236.7	7.92
	Condoulpe		Brown	76	2.54

Table 15.3 Great soil groups, land systems, soil types and areas

Great Soil Groups associated with ASC* order[1]	Land systems[2]	ASC order (Soil type)	ASC sub-order (Variant)	Area mapped within project boundary[3]	
				(ha)	(%)
Solodized solonetz and solodic soils, some soloths and red-brown earths, desert loams	Rata	Sodosol	Red	273.2	9.14
	Condoulpe, Marma		Brown	640.9	21.4
	Rata		Grey	34	1.1
Black earths, grey, brown and red clays	Condoulpe	Vertosol[6]	Brown	32.6	1.09
	Hatfield		Grey	1.2	0.04
Total				**2,988.8**	
Nepean mine area					
Solonised brown soils, grey-brown and red calcareous soils	Wilkurra	Calcarosol	Hypercalcic	607.6	75.4
Prairie soils, chocolate soils, some red and yellow podzolic soils	Arumpo	Dermosol	Brown	13.2[7]	1.6
Red, yellow and grey earths, calcareous red earths	Arumpo, Bulgamurra, Wilkurra	Kandosol	Red	184.1	22.8
Total				**805.0**	

Notes: *1. From Isbell (2002), Appendix 5.*

2. No soil was sampled from the Youhl land system.

3. Not all of each mine area was mapped for soil type, hence totals may differ to values elsewhere.

4. All individual areas are <20 ha.

5. Area <20 ha.

6. Individual areas of both Brown and Grey Vertosol are <20 ha.

7. Area <20 ha.

** ASC = Australian soil classification.*

A detailed soils investigation was not completed for the injection borefields due to the lower level of disturbance that is likely to be associated with the borefields. Based on existing published mapping, the bulk of the western portion of the borefield would be located on the Gulthul Land System as part of the Lachlan Sand Plains Landscape (as derived from Walker 1991 and Mitchell 2002). That is:

> Extensive slightly undulating Quaternary aeolian sands with isolated sandy hummocks and depressions, relief 4 to 8 m. Loamy to clay loam calcareous earths with limestone nodules frequently exposed, solonized brown soils and sandy red and brown texture-contrast soils ,deep red sands on hummocks and dunes and grey clays in depressions.

The eastern portion of the injection borefield is located mainly on the Rata and Mama land systems which are mainly red brown and grey Sodosols.

Detailed soil investigations were not completed for the water supply pipeline, accommodation facility, borrow pits or access roads because of their pre-existing land systems classifications and relatively small impact area. More information on the soils in these areas is provided in Appendix L.

15.2.4 Land and soil capability

Under the *Land and Soil Capability Mapping of NSW* (OEH 2013b), the West Balranald mine is mapped as predominantly land and soil capability (LSC) Class 5 with some Class 6. The Nepean mine has predominantly Class 7 with small areas of Class 5 and Class 3 (OEH 2013b).

LSC classes and their definitions (OEH 2013b) are shown in Table 15.4.

Table 15.4 Land and soil capability classes

Class	General definition[1]	Limitations[2]
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)		
1	**Extremely high capability land**: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.	**Very slight to negligible limitations.** Land capable of sustaining high impact land uses (eg cultivation) and no special land management practices required.
2	**Very high capability land**: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	**Slight but significant limitations.** Land capable of sustaining high impact land uses which can be managed by readily available, and easily implemented management practices.
3	**High capability land**: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	**Moderate limitations.** Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)		
4	**Moderate capability land**: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	**Moderate to severe limitations.** Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (eg grazing).
5	**Moderate–low capability land**: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	**Severe limitations.** Land not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (eg high value crops). Lower impact land uses (eg grazing) can be managed by readily available practices.
Land capable for a limited set of land uses (grazing, forestry and nature conservation		
6	**Low capability land**: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	**Very severe limitations.** Land incapable of sustaining many land use practices (eg cultivation, moderate to high intensity grazing and horticulture). Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing).

Table 15.4 Land and soil capability classes

Class	General definition[1]	Limitations[2]
Land generally incapable of agricultural land use (selective forestry and nature conservation)		
7	**Very low capability land**: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.	**Extremely severe limitations.** Land incapable of sustaining most land uses. Limitations cannot be overcome.
8	**Extremely low capability land**: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	**Extreme limitations.** Land incapable of sustaining any land use and best left undisturbed and managed for conservation.

Note: *1 From OEH 2012.*

2 From OEH 2013b.

An assessment of LSC for the Balranald Project and each soil type was completed based on the soils survey. Both the West Balranald and Nepean mines were been identified (based on the OEH assessment process) as predominantly Class 6, described as:

> Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

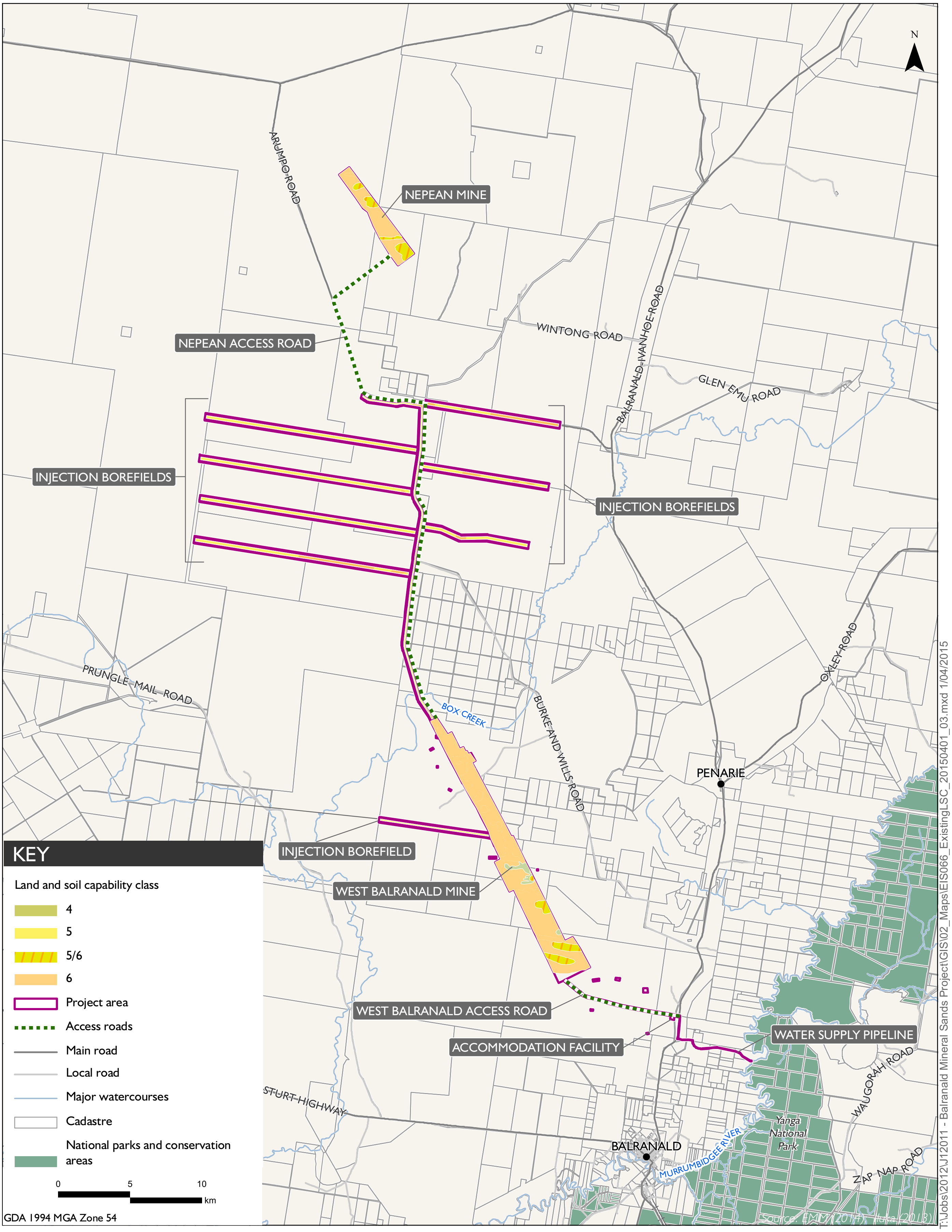
Limitations for Class 6 land are described as:

> Very severe limitations: Land incapable of sustaining many land use practices (eg cultivation, moderate to high intensity grazing and horticulture). Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing).

Land suitability outcomes generally reflect the current and historical uses of the land, being primarily used for low productivity grazing on mainly chenopod (saltbush and bluebush) pasture, or remain uncleared. The LSC classes for each soil type at the West Balranald and Nepean mines are summarised in Table 15.5 and are shown in Figure 15.1.

Table 15.5 Summary LSC classes per soil type

Soil type	LSC class
Calcarosols	
Hypercalcic Calcarosol	6
Hypocalcic Calcarosol	6
Chromosols	4
Dermosols	6
Kandosols	5/6
Sodosols	6
Vertosols	6



EMM
ILUKA

Existing land and soil capability

Balranald Mineral Sands Project

Environmental Impact Statement

Figure 15.1

15.2.5 Biophysical strategic agricultural land

BSAL is land with a rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality (NSW Government 2013). BSAL is able to be used sustainably for intensive purposes, is inherently fertile and generally lacks significant biophysical constraints (NSW Government 2013).

Division 3 of Part 4A of the Mining SEPP states that any DA for mining on BSAL must be accompanied by a gateway certificate or site verification certificate that certifies that the land on which the proposal is to be carried out is not BSAL. A site verification certificate is only needed when broad-scale government mapping identifies that the land contains BSAL.

No government-mapping BSAL has been undertaken in the project area or more broadly in the Balranald LGA or surrounding regions. Therefore, an assessment was completed in accordance with the OEH (2012) guidelines to determine if BSAL was present. It concluded that:

- the mine area does not lie within the 350 mm and above rainfall isohyet for 9 out of 10 years;
- the mine area does not overlie a groundwater resource declared by the NOW as highly productive groundwater; and
- the mine area does not lie within the area mapped by the NOW as being within 150 m of a highly reliable surface water supply.

Local rainfall recharge of regional groundwater systems is extremely low due to the low annual rainfall and high evaporation rates. Depth to groundwater is generally greater than 10 m, except along the major river channels. Directly beneath the West Balranald and Nepean mine areas the depth to groundwater is approximately 20 m below ground level. There is a general trend of salinity concentrations in all water bearing units to increase linearly from east to west, in line with groundwater flow direction. The average EC measurement for the Shepparton Formation is 48 mS/cm, and 56 mS/cm for the LPS. Furthermore, there is no alternate access to a highly reliable surface water supply via an easement.

The BSAL assessment of site conditions determined that no BSAL occurs in the West Balranald or Nepean mine areas. All soils sampled failed the criteria for fertility and most failed additional BSAL criteria such as salinity and chloride levels.

15.3 Impact assessment

Potential impacts of the Balranald Project on soil resources are associated with temporary loss of land due to construction and operation of mine infrastructure (eg surface facilities) and open cut mining. Activities may impact on soil physical and chemical properties and post-mining land use capability due to:

- excavation of soil;
- temporary storage of overburden adjacent to the pit during mining;
- long-term storage of soil in stockpiles;
- compaction of soil by machinery and infrastructure placement;

- contamination of soil resulting from storage of fuel and chemicals, refuelling activities, hydrocarbon spills, saline water spills, etc;
- sterilisation when areas of land able to support agricultural uses are cut off from other suitable areas, or reduced in size to be no longer viable for those land uses; and
- loss of soil through wind and water erosion.

These activities can reduce the capability of land and soils and also reduce its quality as agricultural land.

15.3.1 Erosion potential

A number of soils in the disturbance area have high erosion potential. The potential for soils to erode determines the applicability of management measures and whether the soils are appropriate for use in rehabilitation activities. The erosion potential of soils (also taking account of their landscape position) at the West Balranald and Nepean mines is summarised in Table 15.6.

Table 15.6 Summary of erosion potential

Soil type	Water erosion	Wind erosion
Calcarosols		
Hypercalcic Calcarosol	Variable (mainly low to moderate)	Moderate to high
Hypocalcic Calcarosol	Low	High
Chromosols	Low to moderate	Moderate to high
Dermosols	Low	Moderate to high
Kandosols	Variable (mainly moderate to high)	High
Sodosols	Low	Moderate to high
Vertosols	Low	Low

15.3.2 Post-mining land and soil capability

Potential changes to LSC of the project area following mining and rehabilitation are presented in Table 15.7 and shown in Figure 15.2.

Table 15.7 Changes to land and soil capability

Area	Pre-mining LSC	ha	Post-mining LSC	ha	Change	Comment
Calcarosols-hypercalcic	6	1,463.73	6	1,463.73	No change	-
Calcarosols-hypocalcic	6	51.35	6	51.35	No change	-
Chromosols	4	173.15	6	173.15	Reduction	Very small area changes with negligible consequences
Dermosols	6	6.11	6	6.11	No change for most of area	-

Table 15.7 Changes to land and soil capability

Area	Pre-mining LSC	ha	Post-mining LSC	ha	Change	Comment
Kandosols	5/6	312.82	6	312.82	No change for most of area	-
Sodosols	6	948.23	6	948.23	No change	-
Vertosols	6	33.98	6	33.98	No change	-
Dermosols	6	13.24	6	13.24	No change	-
Calcarosols-hypercalcic	6	607.62	6	607.62	No change	-
Kandosols	5/6	184.15	6	184.15	No change	-

Note: Some post-mining land capability will be class 7 based on final landform; native woody vegetation is to be established for conservation purposes and is not intended to be subject to long term grazing.

As can be seen from the Table 15.7, there will be little change to the post mining land and soil capability when compared to pre-mining conditions. Only a small area of Chromosols will change from Class 4 to Class 6 however, this is considered to be negligible.

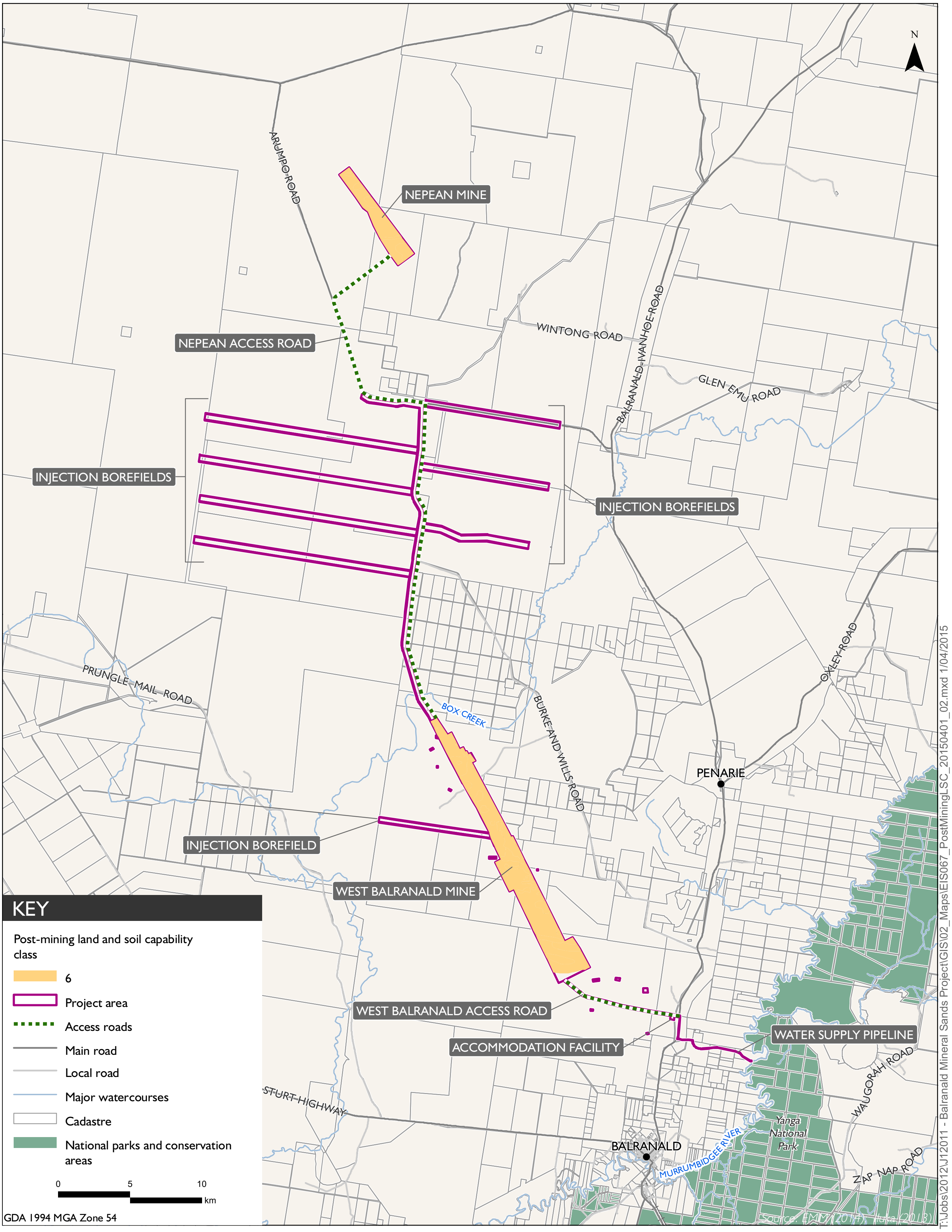
15.4 Management and mitigation

The topsoil and subsoil resources would not be suitable for stripping for reuse (based on standard criteria) due to the predominantly unsuitable soil structure combined with the very shallow topsoil and salinity and sodicity limitations. However, given appropriate stripping, handling and re-establishment techniques it is considered that most soils can be successfully stripped to predetermined depths and reinstated on the final landforms for subsequent establishment of vegetative cover.

Soil resources in the project area that would be impacted by the Balranald Project would generally be managed through:

- installing appropriate erosion and sediment control (ESC) measures prior to disturbance on-site;
- identifying and quantifying the soil requirements for rehabilitation works over the project life based on mine progression, the nature of disturbance and rehabilitation objectives;
- identifying and mapping soil resources (including topsoil and soil with specific management requirements) and locations of stockpiles across the site and managing this information via appropriate systems and databases;
- optimising the recovery of topsoil and useable subsoil during stripping operations;
- stockpiling soil appropriately and managing stockpiled soil to minimise resource degradation (including installation of ESC measures and application of amelioration measures where required); and
- carrying out rehabilitation works in appropriate conditions to minimise deterioration of the soil resource and to maximise rehabilitation success.

Chapter 7 of Appendix L provides greater detail on the above soil resource management practices.



Post-mining land and soil capability

Balranald Mineral Sands Project

Environmental Impact Statement

Figure 15.2

15.5 Conclusion

The field survey and subsequent assessment of survey results indicated that six main soil types (or orders) are found at West Balranald corresponding with 12 soil colour variations (sub-orders). The Nepean mine area was found to be more homogenous than West Balranald with only three soil types and three variants.

Hypercalcic Calcarosols is the most common soil type at both the West Balranald and Nepean mines (75.4%). Brown Sodosols and Red Kandosols are the second most common soil types at the West Balranald and Nepean mine areas, respectively. Red Dermosols and Grey Vertosols are the least extensive soil types found across the mine areas. Characteristics of the predominant soils in the project areas include:

- very shallow topsoils with very low organic matter levels;
- significant levels of carbonates, notably in the Calcarosols;
- moderately to strongly alkaline at depth;
- sodicity and salinity levels are high to extreme in most of the clayey soils (eg Sodosols and Dermosols) but lower in the sandy/loamy soils (eg Kandosols); and
- poorly drained and highly infertile.

The surveyed areas within the project area contain no land with potential to be BSAL. The LSC assessment found that the project area predominantly contains Class 6 land indicating that:

> ... Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

There would be very little change to the LSC post mining with no changes to the majority of areas with only the Chromosols area having a very small change with negligible consequences.

An assessment of the suitability of topsoil and subsoil resources for mine rehabilitation has found that most soils would not be suitable for stripping for reuse (based on standard criteria) due to the predominantly unsuitable soil structure combined with the very shallow topsoil and salinity and sodicity limitations noted above.

However, with the implementation of the management and mitigation measures outlined in Section 15.4 and Appendix L, it is considered that most soils can be successfully stripped to predetermined depths and reinstated on the final landforms for subsequent establishment of vegetative cover with appropriate stripping, handling and re-establishment techniques.

16 Land use

16.1 Introduction

The SEARs require an assessment of potential impacts on land use due to the Balranald Project, including:

an assessment of the likely impacts of the development on the soils, land capability, and landforms (topography) of the site; and

an assessment of the compatibility of the development with other land uses in the vicinity of the development in accordance with the requirements in Clause 12 of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*;

Impacts to soil resources and land capability are addressed in Chapter 15 and Appendix L, and impacts to landforms are addressed in Chapter 17 and Appendix M.

The SEARs also require an assessment of the compatibility of the Balranald Project with other land uses. Land uses are primarily agricultural in the vicinity of the project area. An agricultural impact statement (AIS) was prepared for the Balranald Project (Appendix C) and is summarised in this chapter.

The AIS was prepared in accordance with the following regulations, methods and guidelines:

- *Strategic Regional Land Use Policy* (SRLUP) (DP&I, 2012a); and
- *Strategic Agricultural Land Use Policy: Guideline for Agricultural Impact Statements* (DP&I, 2012b).

16.2 Existing environment

16.2.1 Regional agricultural land use

The Balranald LGA is the area referenced when identifying 'regional' agricultural resources and impacts. Agriculture is the major industry in the Balranald LGA, accounting for 96% of all land uses.

Land uses within the Balranald LGA compromise mostly of agricultural pastoral activities (grazing livestock with some winter cereal cropping) with some fruit growing and quarrying of gypsum and other minerals. Agricultural land is almost exclusively used for grazing, utilising 95% of all agricultural land. Dryland cropping enterprises comprise a minor portion of agricultural activities at 1%. The primary crops grown are cereals for grain, mainly wheat and barley. Irrigation occurs over only 0.4% (approximately 8,000 ha) of the total agricultural area (ABS 2011).

The project area is approximately 0.46% of the total area of the Balranald LGA.

16.2.2 Regional agricultural employment and production value

Agriculture (and related industries) is a major employer within the Balranald LGA; the total number of persons employed in the agricultural sector represents 31% of the total employed population (ABS 2011). Detailed agricultural employment figures are not available for the project area specifically; however based on the existing agricultural land uses within the project area, it is expected that income from agricultural enterprises within the project area is generated from sheep meat, wool and winter cereal cropping.

The latest agricultural production value for the Balranald LGA are from the 2006 Census which states a total agricultural value of $83 million (ABS 2006), as detailed in Table 16.1. The main agricultural production by value is dryland crop production (note that this accounts for only 3.3% of the LGA agricultural land use), and irrigated wine grape growing. Income from livestock is mainly derived from the sheep industry, with lamb (livestock and slaughtering) and wool (livestock products) sales providing the bulk of income.

Table 16.1 Balranald LGA agricultural production value (2006)

Agricultural production gross value	Balranald LGA ($M)
Crops	57.2
Livestock slaughtering	17.4
Livestock products	8.4
Total gross agricultural production	**83.0**

Source: ABS 2006.

16.2.3 Pre-mining potential agricultural production value

Potential agricultural productivity was determined using DPI gross margin budgets and agricultural productivity data for agricultural enterprises suitable for each of the land and soil capability classes that would be impacted (see Chapter 15). The analysis has been undertaken on the potential capability of the land, rather than current land use. This information can be used to generate potential farm incomes using gross margin budgets.

Iluka is currently assessing the potential for continued use of agricultural land within the project area which would not be disturbed by mining and related activities in discussions with landholders. Continued use of land for agricultural activities would also aid in preventing the build-up of fuel loads and subsequent bushfire risk.

Progressive rehabilitation of the project area is proposed. Therefore, the entire disturbance area (5,346 ha) would not be completely removed from potential agricultural production at once, but rather it would comprise four different areas, each dependant on the stage of the project:

- undisturbed (pre-mining);
- pre-mining preparation, including clearing of vegetation and topsoil stripping;
- mining; and
- rehabilitation.

Whilst the project area is 9,964 ha, the purpose of an AIS is to assess the agricultural impact of a project on agricultural resources, for this reason the assessment firstly focuses on the soil assessment area (3,794 ha) within the project area, and the potential agricultural production within this area using a conservative assessment (ie total removal of these areas from agricultural production for the life of the project).

Secondly the assessment quantifies potential agricultural production of the soil assessment area excluding the area covered by SMCAs (which cover a total of 1,067 ha within the soil assessment area); this area is referred to herein as the area of actual agricultural disturbance covering 2,727 ha. The location of the SMCAs in relation to the project area is shown in Figure 3.2. This assessment has been undertaken due to the SMCAs not being available at present for agricultural production.

Actual farm enterprises being conducted within the vicinity of the project area are dependent on numerous factors, including soil and vegetation type, water quality and availability, property history and landholder preference. The following five farm enterprises have been identified as operating within or alongside the project area:

- 20 micron Merino ewes for wool and meat production (DPI 2014a);
- feral goats for meat production (Western CMA 2011);
- dorper ewes for meat production (DPI 2014b);
- weaner cattle for beef production (I&I 2012); and
- short fallow dryland cropping for wheat production (DPI 2012a).

The 'average' safe carrying capacity determined for the Balranald LGA is one dry sheep equivalent (DSE) per 4 ha (equivalent to 0.25 DSE/ha), according to the *Balranald Common Plan of Management* (BSC 2010). This 0.25 DSE/ha carrying capacity has been assumed as the 'average' for LSC Class 6 land, as LSC Class 6 comprises the majority of the soil assessment area and the area of actual agricultural disturbance. The better rated land (Class 4 within the project area) gives a higher DSE carrying capacity whilst the inferior LSC rated land (Class 5 and 6 within the project area) gives a lower DSE carrying capacity. These assumed ratings are based on the fact that the 'better' rated LSC land would have a higher inherent fertility and soil moisture holding capacity, as described in the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH 2013).

Table 16.2 summarises the potential gross margin for each of the five agricultural enterprises identified, calculated for both the soil assessment area (3,794 ha), and the area of actual agricultural disturbance (2,727 ha). SMCAs have not been included in the potential agricultural production of the area of actual agricultural disturbance as by definition they are not currently being used for agricultural production.

Gross margins for grape or other irrigated fruit production have not been calculated as both soil type (sodicity and salinity) and water quality (salinity) are unsuitable for the growing of vines and fruit trees within the project area.

Table 16.2 Pre-mining gross agricultural margin per enterprise for the MDA and ADA

Enterprise	Average gross margin per hectare ($)	Total potential income per annum	
		Soil assessment area	Agricultural disturbance area
Merino Ewe and Merino Ram	$6.95	$26,382	$18,979
Feral goat	$1.20	$4,553	$3,272
Dorper Ewe and Dorper Ram	$6.05	$22,947	$16,531
Beef Cattle Inland Weaner	$4.85	$18,413	$13,265
Wheat Cropping Short Fallow	$179	$30,967	$30,251

Based on the nominated gross margins, the most profitable enterprise mix would be wheat production on the 173 ha of LSC Class 4 land combined with a Merino ewe enterprise on the remaining 3,621 ha of LSC Class 5/6 and LSC Class 6 land.

Given the calculated gross margins the soil assessment area has the potential to generate an estimated gross margin of $55,521 per annum from a Merino ewe enterprise (on LSC 5/6 and LSC 6 land) combined with a wheat cropping enterprise (LSC 4), whilst the area of actual agricultural disturbance has the potential to generate a potential gross margin of $47,472 per annum from the same Merino ewe enterprise combined with a wheat cropping enterprise. In addition there is the 'opportunity' enterprise of mustering feral goats for sale with an annual gross margin of $4,553 for the soil assessment area and $2,727 across the area of actual agricultural disturbance.

It is important to note that these figures are derived from the optimum potential uses and production outcomes and are likely to be much higher than the actual incomes being achieved at the time of publication. Whilst wheat cropping is the most productive enterprise by gross margin analysis this is assuming 160 mm of in-crop rainfall each cropping season. On a year to year basis the Merino ewe enterprise would be expected to be the most profitable.

16.3 Impact assessment

The SEARs require an assessment of the compatibility of the Balranald Project with other land uses in the vicinity of the project area in accordance with the requirements in Clause 12 of the Mining SEPP, which sets out matters for consideration of the consent authority. The requirements of clause 12 of the Mining SEPP and where they are addressed in this EIS are listed in Table 16.3.

Table 16.3 Assessment against the requirements of clause 12 of the Mining SEPP

Clause 12 considerations	Section addressed in this EIS
(a) consider: (i) the existing uses and approved uses of land in the vicinity of the development, and	The existing land uses within and in the vicinity of the project area are agricultural. Impacts to agricultural production are addressed in Section 16.3.1. The project area also includes land with conservation use (ie the SMCAs). Impacts to SMCAs are addressed in Section 16.3.3 and Chapter 12.
(ii) whether or not the development is likely to have a significant impact on the uses that, in the opinion of the consent authority having regard to land use trends, are likely to be the preferred uses of land in the vicinity of the development, and	An assessment of the agricultural production value potentially impacted by the Balranald Project has been completed in Section 16.3.1.
(iii) any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses, and	The Balranald Project will temporarily remove existing land uses within the project area as described in this chapter. However, the rehabilitation and closure strategy (Chapter 17 and Appendix M) would include progressive rehabilitation of disturbed areas throughout the life of the project. The proposed final land use would be consistent with pre-mining land uses.
(b) evaluate and compare the respective public benefits of the development and the land uses referred to in paragraph (a) (i) and (ii), and	The Balranald Project will provide considerable economic activity to the regional economy, which would be greater than the potential activity generated by the impacted agricultural resources, as outlined in Chapter 16 and 20.
(c) evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a) (iii).	The rehabilitation and closure strategy (Chapter 17 and Appendix M) would include progressive rehabilitation of disturbed areas throughout the life of the project. The proposed final land use would be consistent with pre-mining land uses. Measures minimise incompatibility with agricultural land uses are addressed in Section 16.4.

16.3.1 Agricultural production

i Temporary disturbance

The Balranald Project would temporarily remove 3,794 ha of LSC classes 4, 5/6 and 6 from potential agricultural production during the life of the project (approximately 10 years). These areas would be progressively rehabilitated to a land use and vegetation type in accordance with the rehabilitation and closure strategy (Appendix M).

Two separate analyses have been carried: potential income lost as a result the entire soil assessment area being temporarily removed from agriculture, and potential income lost as a result of the area of actual agricultural disturbance being temporarily removed from agriculture.

Potential gross margin determination for both the soil assessment area and the area of actual agricultural disturbance was calculated using the most productive agricultural enterprises for each LSC class, with LSC Class 4 land being utilised for wheat cropping, whilst LSC classes 5/6 and 6 were running a Merino ewe enterprise. A summary of gross margins for temporary disturbance is provided in Table 16.4.

Table 16.4 Summary of gross margins for temporary disturbance

Land and soil capability class	Soil assessment area		Potential gross margin	Actual agricultural disturbance area		Potential gross margin
	ha	%		ha	%	
4	173	4	$30,967	169	6	$30,251
5/6	497	13	$3,936	256	9	$2,028
6	3,124	83	$20,618	2302	85	$15,193
Total	**3,794**	**100**	**$55,521**	**2,727**	**100**	**$47,472**

The estimated net annual economic impact on potential lost agricultural productivity as a result of the temporary removal of land is $55,521 per annum across the soil assessment area and $47,472 per annum over the area of actual agricultural disturbance.

The estimated net annual economic impact on potential agricultural productivity after final landform and rehabilitation reaches completion is a net loss of $22,775 per annum. This is as a result of final landform being nominated as LSC Class 6 across the soil assessment area, aside from 52 ha nominated as final void which is assumed in this assessment to have no potential agricultural use. This would result in a net decrease of LSC Class 4 (173 ha) and LSC Class 5/6 (497 ha), and an increase of LSC Class 6 land, increasing the potential grazing area and subsequently reducing the potential cropping area.

However, there would also be a net increase in the amount of land available for agricultural activity as a result of the Balranald Project, due to the conversion of SMCAs within the soil assessment area from non-agricultural use to potential Merino sheep grazing as outlined in the rehabilitation and closure strategy. Gross margin information was determined using a conservative assessment and assumed the more productive agricultural use of grazing land LSC Class 6 (Merino ewes) upon final rehabilitation. Therefore, once rehabilitation is carried out there could actually be a net gain in agricultural land within the project area of 1,067 ha which equates to an increase in agricultural land within the soil assessment area of 39% due to the inclusion of SMCAs which were not previously available to be utilised by agricultural enterprises.

ii Permanent disturbance

Potential permanent impacts of the Balranald Project on agricultural land are from the proposed biodiversity offset sites and the final void, which would result in land in the order of 28,052 ha of land being permanently removed from potential agricultural production.

As discussed in Chapter 12, biodiversity offsets would be required for the Balranald Project. At this stage of the project, actual biodiversity offset sites have not been determined. However, based on a preliminary calculation of the nature and extent of offsets likely to be required, it is estimated that approximately 28,265 ha of offset lands could be required. The actual size and nature of the offsets would be determined at a later stage of the project. As such, for the purposes of this assessment, it has been assumed that in the order of 28,000 ha would be required for offsets.

Using gross margin data calculated in Section 16.3.1, and assuming none of the biodiversity offset sites are currently used for cropping enterprises (i.e. they have no or only limited clearing of native vegetation) a worst' case scenario of 28,000 ha of LSC Class 5/6 grazing land being permanently removed from agricultural production has been assessed. With a Merino ewe enterprise having a gross margin or $7.92/ha for LSC Class 5/6 land, the resulting biodiversity offsets would reduce potential income from agricultural enterprises by $221,760 per annum.

At completion of the Balranald Project, the final void at the West Balranald mine would permanently remove approximately 52 ha from potential agricultural production. Using the same gross margin calculations, this would result in a loss of potential agricultural income of $412 per annum. There would be no final void at the Nepean mine.

16.3.2 Biophysical strategic agricultural land

The soil resource assessment (Appendix L) found there was no potential BSAL within the Balranald Project area; therefore the Balranald Project would have no impact on BSAL.

16.3.3 Southern mallee conservation areas

In the soil assessment area there is 1,067 ha of SMCA, of which the majority is Mallee scrub with limited agricultural value in its current state. Upon rehabilitation of the soil assessment area, the area of land available for productive agricultural use would potentially increase by approximately 1,067 ha of potential grazing land (LSC Class 6). This resumption of SMCAs would have a positive impact on the total area available for agricultural production. It is noted that the final use of the project area would subject to any future changes to the WLL conditions for the impacted land parcels.

16.3.4 Surface water

The Balranald Project is unlikely to have a significant impact on local or regional flooding or surface waters. It is predicted that the Balranald Project would have minimal impact on surface water resources, as addressed in Chapter 14.

16.3.5 Groundwater

The majority of water that would be extracted from regulated groundwater sources is hypersaline which cannot be used for agricultural production (of which most would be returned to the water source via injection) and would have no impact on agricultural productivity.

There would be two sources of non-hypersaline water used for the project. The first would water extracted from the Olney Formation during the construction phase. It is estimated that approximately 150 ML/year would be extracted. Due to salinity and low yields this water is not suitable for irrigated cropping, and as such would have minimal impact on agricultural production.

The project would also require a fresh water supply of approximately 435 ML per annum (rounded up to 450 ML) from the Murrumbidgee River which is considered a supply of water that could otherwise have been used for agricultural activities, such as irrigated winter cereal cropping. A conservative assessment of the value of this water was made, assuming that all of this water could have been be used for irrigated wheat cropping. The gross margin for the production of flood irrigated wheat has been calculated, and compared to the alternate use of dryland cropping. Wheat requires 2.5 ML/ha (DPI 2012b); therefore, a maximum of 180 ha of irrigated wheat could be farmed annually using the 450 ML of purchased water. The gross margin for this enterprise is $664 per ha and, at a yield of five tonnes per ha (DPI 2012b).

With this water temporarily not being available for agriculture it is assumed that the equivalent area of land would otherwise be used for dryland cropping with productivity levels of LSC Class 2 (ie land suitable for irrigated cropping). The estimated net annual economic impact on potential agricultural productivity as a result of using this land for dryland cropping ($298 per ha) rather than irrigated cropping ($664 per ha) is lowering the potential gross annual income by $66,060. When compared to the $83M generated in agricultural production within the Balranald LGA, a loss of $66,060 would be considered a minimal impact.

16.3.6 Economic impacts

The economic assessment for the Balranald Project (Appendix P) predicted there would be no significant adverse direct or flow-on economic impacts to the regional agricultural sector as a result of the Balranald Project.

16.4 Management and mitigation

The Balranald Project has been developed to avoid and minimise land disturbance and overall impacts on agricultural land where possible. The rehabilitation and closure strategy for the Balranald Project (Chapter 17 and Appendix M) would increase the overall agricultural capacity of the project area compared to its existing capacity, as a small area of current SMCAs impacted by the Balranald Project would be converted to an agricultural use post-mining.

Agricultural land resource management for the Balranald Project would include:

- minimising disturbance to agricultural land, where practicable;
- management of soil resources within the project area including:
  - identification and quantification of potential soil resources for rehabilitation;
  - optimisation and recovery of useable topsoil and subsoil during stripping operations;
  - management of soil reserves in stockpiles so as not to degrade the resource;
  - establishment of effective soil amelioration procedures to maximise the availability of soil reserve for future rehabilitation works and provide benefit during final rehabilitation;
  - use of appropriate soil ameliorants (e.g. gypsum) to improve structure of sodic soils during rehabilitation, and as such improve future agricultural potential; and

- inclusion of agricultural lands in the rehabilitation and closure strategy.

16.5 Conclusion

The assessment of impacts to land use has been prepared in accordance with the SEARs for the Balranald Project and the *Agricultural Impact Statement Guidelines* (DP&I 2012a) which seeks to balance economic growth in rural NSW with the sustainable management and use of natural resources and agricultural land.

The soil assessment area of 3,794 ha and has a potential annual gross margin of $55,521 per annum. The area currently utilised for agricultural enterprises, assessed as the area of actual agricultural disturbance has a potential annual gross margin of $47,472. The post-mining potential gross margin for the soil assessment area is expected to decrease by $22,775 annually, however there would be a net increase of 1,067 ha land available for livestock production, primarily through increase grazing area resulting from the resumption of the SMCAs.

Land permanently removed from potential agricultural production comprises approximately 28,000 ha required for biodiversity offsets (refer to Chapter 12), and an estimated 52 ha associated with the proposed final void at the West Balranald mine. Irrigation water temporarily removed from potential agricultural production totals 450 ML per annum from the Murrumbidgee Regulated River WSP. No groundwater would be removed from irrigators as a result of the project. The impact to existing groundwater users within the vicinity of the project area is predicted to be minimal.

Rehabilitation of disturbed areas would be progressive throughout the life of the project. The proposed final land use is consistent with pre-mining land uses.

On balance, the Balranald Project would provide considerable economic activity to the regional economy. This activity is much greater than the potential activity generated by the impacted agricultural resources (Gillespie Economics 2015). The Balranald Project would provide economic benefits to the region and would minimise impacts on surrounding agricultural resources and dependent industries.

17 Rehabilitation

17.1 Introduction

The SEARs require a rehabilitation strategy for the Balranald Project. They state that the EIS must include:

> a rehabilitation strategy, dealing with NSW Trade and Investment's requirements.

A rehabilitation and closure strategy for the Balranald Project was prepared by EMM (Appendix M). The RCS was prepared in accordance with the following regulations, methods and guidelines:

- *Mining Act 1992*;
- EDG03 – *Guidelines to the Mining, Rehabilitation & Environmental Management Process* (NSW Department of Trade and Investment 2012);
- *The Strategic Framework for Mine Closure* (ANZMEC and MCA 2000);
- *Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry* (Commonwealth of Australia 2006); and
- *Mine Closure and Completion - Leading Practice Sustainable Development Program for the Mining Industry* (Commonwealth of Australia 2006).

This chapter is a summary of the RCS in Appendix M.

17.2 Rehabilitation objectives

The primary objectives for rehabilitation of the project area are to:

- create safe, stable and non-polluting landforms;
- restore self-sustaining ecosystems suitable for a final use determined in consultation with landholders and relevant government agencies; and
- progressively rehabilitate disturbed areas to make best use of favourable climatic and intrinsic conditions.

The secondary objectives are to:

- establish a 'base-case' plan that can be reviewed and updated during the life of the project;
- provide relevant information upon which stakeholders can comment and have input through the approval process; and
- ensure that closure planning (including accountability and resourcing) is incorporated into the on-going project operations.

The above objectives are considered consistent with the Mining Act and relevant government guidelines.

17.3 Operational rehabilitation

The following sections describe the general strategies and methods that would be implemented prior to and during operations in order to facilitate an effective rehabilitation program.

17.3.1 Seed collection

Where possible, seed would be collected from the disturbance area prior to ground disturbing activities.

It is possible that some plant species required for rehabilitation will not be able to be grown from seed collected from the disturbance area. In this case, discussion with OEH and/or DRE will be undertaken to use off-site plant material.

17.3.2 Vegetation clearing

Clearing of vegetation would be required ahead of the mining activities. Clearing of native vegetation would be performed in accordance with procedures developed specifically to meet the rehabilitation objectives for the project area.

Some overstorey timber would be retained and stockpiled for habitat enhancement purposes (see Section 17.6.5), the remainder may be mulched and stockpiled separately. For low open shrubland areas it may be appropriate to clear the understorey with the top soil layer. In other areas, the understorey may be cleared separately to the top soil.

A range of techniques would be considered for vegetation clearing depending on the location within the project area.

17.3.3 Surface soil stripping, stockpiling and management

The following would be considered when stripping top soil:

- top soil from different vegetation communities (where appropriate) would be maintained in separate stockpile categories;
- records would be maintained of top soil movements including soil type, quality, location, vegetation community, weeds present (if any), removal date, storage location and dust suppression treatment (if any);
- stripping would be completed in a way that, where possible, retains biological activity in the top soil and sub soil (which in turn would aid rehabilitation);
- the volume of soil retained and subsequently required for rehabilitation would be determined by availability (ie area available to be stripped and depth of stripping);
- earthmoving plant operators would be trained and supervised to ensure that stripping operations are conducted in accordance with stripping plans and in situ conditions;
- soil, where possible, should be stripped in a slightly moist condition and appropriate machinery would be used to minimise structural degradation without being trafficked or deep ripped prior to stripping;

- deep ripping may be necessary for deeper layers followed by dozing or scraping to remove the remainder of the soil with care taken not to mix any remaining top soil with sub soil;

- where practical the inclusion of obviously poorer quality material would be avoided (eg material dominated with stones);

- all machinery used in the stripping operation would be inspected to ensure that it is clean and free of soils and weed seeds prior to mobilisation;

- disturbance areas would be stripped progressively (ie only as required); and

- rehabilitation of disturbed areas (ie roads, embankments and batters) would be undertaken as soon as practicable after these structures are completed or as areas are no longer required.

Subsoil would be stripped separately to the top soil and stockpiled separately. The placement of sub soil during rehabilitation activities needs to be assessed with reference to the landscape position it was stripped from.

Once stripped, top soil and sub soil would be stockpiled for rehabilitation as follows:

- soil types with significantly different properties should be stockpiled separately;

- stockpiles would be located so that they would not be further disturbed by mining activities and positioned to avoid surface water flow;

- erosion and sediment controls would be installed around stockpile areas and regularly maintained;

- locations of stockpiles would be recorded using GPS and an inventory of data relating to the soil type, volumes and use in rehabilitation maintained by appropriate personnel;

- topsoil stockpiles would be retained at a height of no more than 2 m, while subsoil can be stockpiled to a maximum of 10 m dependent on soil properties, with slopes of both top soil and sub soil stockpiles no greater than a grade of approximately 1V:3H and a slightly roughened surface to minimise erosion;

- where ameliorants such as lime, gypsum or native suitable fertiliser are needed to improve the condition of stripped soil, it will be either applied to the stockpiles in-between the application of separate layers from the scrapers, or be spread on the soil prior to scraping;

- vehicle access on soil stockpiles would be prohibited except when necessary for soil quality monitoring; and

- weed management will be applied to stockpiles to minimise the accumulation of weed seed in the soil.

17.3.4 Overburden removal, handling and backfilling

Overburden would be removed using earthmoving equipment such as scrapers, excavators, shovel and trucks. Saline groundwater would not be used to control dust during top soil, sub soil or overburden stripping unless it can be shown that groundwater quality would not affect rehabilitation outcomes.

The majority of SOB would be returned directly to the backfill face and would not need to be stockpiled, except for initial stages of mining during the establishment of the initial boxcut. NSOB would be managed through a combination of stockpiling and replacement in the pit as backfill, or, retained in stockpile and rehabilitated, or returned directly to the backfill face.

Rehabilitation material volumes necessary to complete the earthworks associated with rehabilitation are summarised in Table17.1.

Table 17.1 Summary of rehabilitation material volumes

Mine	Rehabilitation material volumes (Mm^3)							
	SOB		NSOB			Tailings	MBP[4]	Final void volume (following reshaping to 1:10)
	Stockpiled and then backfilled	Backfilled immediately	Stockpiled and then backfilled	Backfilled immediately	Stockpiled - part of final landform	capped	All backfilled - at West Balranald	
West Balranald	5.5	128.0	26.8	26.7	16.1	NSOB s/p #6 is for capping TSF	8.3	5Mbcm
Nepean	n/a	n/a	5.9	29.2	n/a	n/a	2.3	<1 Mbcm

17.3.5 Acid mine drainage management implications for rehabilitation

Assessment of the geochemical characteristics of the ore body and overburden has been undertaken. Table 17.2 provides a summary of the handling and storage methods to mitigate any effect from potential acid mine drainage.

Table 17.2 Summary of overburden and ore geochemistry and storage strategies

Material		PAF/NAF	General geochemical properties	Storage Infrastructure	
				Operational storage (Short-Term)	Final storage (post-mining)
West Balranald mine	Overburden- non saline (NSOB)	NAF	Shallow, high in natural organic matter, above water table, low potential for leaching salts or metals.	Stockpiled (more than 6 months).	Used for revegetation or final covers where possible (as identified in rehabilitation methods).
	Overburden- saline (SOB)		Below water table, high in salinity, leaching of constituents elevated in saline groundwater including Na, Cl and Sulphate.	Stockpiled (initial boxcut ~6-30 months).	Returned to the pit.
	Overburden organics (OOB)	PAF	Highly reactive; testing shows a strong tendency to acidify rapidly. May generate acid, sulphate and metals.	Stockpiled (initial boxcut) 3 - 4 months.	This material is preferentially placed (over the overburden) into the pit void. It would remain dry for a brief period prior to rewetting due to groundwater recovery.
	Ore	PAF	Highly reactive; testing shows a strong tendency to acidify rapidly. May generate acid, sulphate and metals.	Transferred to ROM pad for a minimum of approximately 4 weeks prior to processing.	Transferred to the MUP for processing.
Nepean mine	Overburden	NAF	Non-reactive, showing a rapid leaching of soluble salts at moderate concentrations.	Stockpiled (initial boxcut ~6-30 months).	Returned to the pit.
	Ore	NAF	Non-acid forming but initially elevated in macro constituents.	Transferred to ROM pad for ~4 weeks prior to processing.	Transferred to the MUP for processing.
Process stream materials (underflow, sand tails, modified co-disposal (ModCoD), MBP)		All PAF	Most are acid forming with variable rates of reactivity.	Refer geochemistry assessment.	Once dried, are mostly placed into lower levels in the West Balranald pit void. Some would remain in TSF to be capped with NAF material.

17.4 Decommissioning

The following sections summarise the key aspects related to the decommissioning and closure of the various infrastructure components of the Balranald Project.

17.4.1 Mine services

All services including power, water and telecommunications would be isolated, disconnected and terminated to make them safe. Generally all underground services would be made safe and left buried in the ground. Overhead power lines would be removed and the materials (ie poles and wire) recovered for potential re-sale or recycling as applicable.

17.4.2 Infrastructure and buildings

The decommissioning of infrastructure and buildings would include:

- de-watering and de-silting of sumps prior to demolition;
- de-oiling, degassing, depressurising and isolation of equipment;
- the removal of all hazardous materials;
- removing or demolishing all buildings, including the administration building, workshop and processing facilities from site;
- breaking all concrete footings up to at least 1.5 m below the surface;
- all wastes would be assessed and classified in accordance with the *Waste Classification Guidelines* (DECC 2008) prior to disposal; and
- inert concrete waste would be crushed and then buried in the final void.

Where possible, assets may be re-used at, or sold to, other mines. After the completion of decommissioning, all areas would be reshaped, deep ripped, subsoiled, topsoiled and seeded in accordance with the RCS.

17.4.3 Roadways, car parks and hardstands

The roadways, car parks and hardstand areas around the workshop and administration areas would be ripped up and the inert waste material placed in the final void. All areas would then be reshaped, deep ripped, top soiled and seeded as required.

17.4.4 Fuel storages

Leading up to closure, a preliminary sampling and analysis program would be implemented to determine whether a more detailed contamination assessment is required for the fuel storages, including the diesel storage and refuelling area, gas storages and area where other hydrocarbons and chemicals are stored. This would assist to quantify the amount (if any) of contaminated material requiring remediation on-site or sent off-site for disposal at a licensed facility.

17.4.5 Water storage infrastructure

Water storage infrastructure would be decommissioned as follows:

- all sedimentation basins which assist in water flow from the final rehabilitated surface would be retained following closure;
- all basins would be assessed for structural integrity and upgrade works completed if the dam is to be retained;
- any remaining basins that are not required would be removed and the original drainage paths re-established wherever possible; and
- drainage lines would be restored with adequate controls to minimise the erosion within the channel, along with controls to prevent the migration of any erosion upstream or downstream.

17.4.6 Borrow pits

Borrow pits will be closed and rehabilitated earlier if the resource is exhausted prior to mine closure. Rehabilitation of borrow pits will typically include:

- removal of all infrastructure from site;
- deep ripping of compacted areas;
- placement of any material that was not suitable for construction purposes back into the excavation;
- pit walls will be battered to an appropriate angle to ensure they are safe, stable and suitable for the surrounding land use;
- previously stockpiled topsoil will be spread over the final landform and disturbed areas; and
- revegetation, seeding and/or planting (depending on the final land use).

17.5 Post mining land use

Establishment of native vegetation communities suitable for intermittent and low intensity grazing uses is the preferred final land use option. However, most areas are unlikely to be suitable for any form of grazing until such time that a successful and sustainable coverage of vegetative rehabilitation has been achieved.

The Balranald Project was broken up into seven domains as defined in the *Guidelines to the Mining, Rehabilitation & Environmental Management Process* (NSW Department of Trade and Investment 2012). Domains are defined as land management units within the Balranald Project with similar geophysical characteristics.

The seven proposed primary domains and secondary domains and their respective areas in terms of operational impact area are listed in Table 17.3. Revegetation of the domains from seed collected prior to ground disturbing activities and topsoil stockpile seed stores will be as follows:

- final void: selected native revegetation species following backfilling of the final void (subject to climatic conditions or water availability);
- mine path: belah woodland, dune Mallee and Sandplain Mallee;
- final NSOB stockpiles: initial cover crop to stabilise the growth medium material and then reseeding chenopods and other selected native revegetation species;
- residual mine areas (external to pit): regraded to the original ground level, top soiled and then reseeding with selected native revegetation species;
- processing area: reseeding selected native revegetation species, being primarily saltbush with a minor area of native woody species; and
- access roads, accommodation facility, borrow pits and injection borefields: reseeding selected native revegetation species.

Further information on the domains and how rehabilitation would be achieved is detailed in Section 3.6 of the RCS contained in Appendix M.

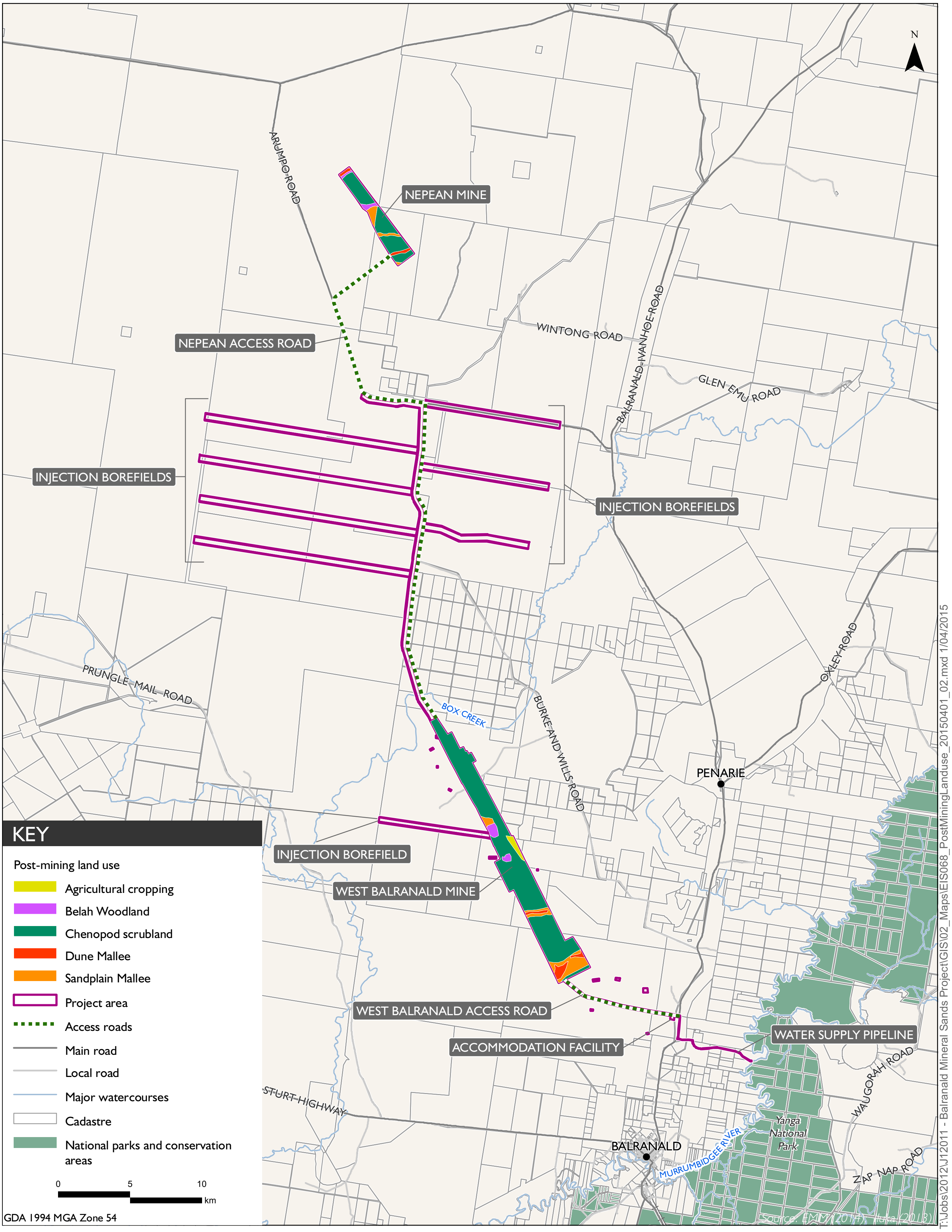
The most significant variation in the post-mining landform compared to pre-mining conditions would be the rehabilitated mine pit, including the final void at West Balranald, and areas where NSOB stockpiles remain in situ. These landforms would be rehabilitated in order to be compatible with the surrounding environment. The final post mining land use is shown in Figure 17.1.

Table 17.3 Primary and secondary domains and final land use

Domain no.	Domain (primary)	Description of uses	Area (ha)	Secondary domain	Secondary domain description	Area (ha)	Pre-mining land use	Final land use
1	West Balranald mine	Mine path/mine void, associated access roads, stockpiles, dewatering infrastructure and gravel extraction areas	2,987	1a:Final Void	Final pit battered to 1:10 plus associated runoff controls and public/stock access protection	40	Grazing on pasture and shrublands	Chenopod shrublands- not grazed (fenced) until stable
				1b: Mine path - backfilled	Backfilled pit- subject to ongoing consolidation – residual depression	506	Grazing on pasture and shrublands	Grazing on chenopod shrublands Native woody vegetation
				1c: NSOB stockpiles	Final rehabilitated stockpiles #1 to #5	151	Grazing on pasture and shrublands	Grazing on chenopod shrublands Native woody vegetation
				1d:Residual mine area (external to pit)	Access pathways/service roads, former stockpile site footprints	2,290	Grazing on pasture and shrublands	Grazing on chenopod shrublands Native woody vegetation
2	Nepean mine	Mine path, associated access roads, dewatering infrastructure	804	2a:Final mine path backfilled including residual depression	Backfilled pit- subject to ongoing consolidation	136	Grazing on pasture and shrublands	Grazing on chenopod shrublands Native woody vegetation
				2b:Residual mine area (external to pit)-	Access pathways/service roads, former stockpile footprints	668	Grazing on pasture and shrublands	Grazing on chenopod shrublands
3	West Balranald processing area	Processing plant, tailings storage facility, maintenance areas/workshops, final product stockpiles and truck load-out area, administration offices and amenities, top soil and other material stockpiles, internal road network and ancillary infrastructure	71	3a: TSF	Capped TSF and associated main collection dam	26	Grazing on pasture and shrublands	Grazing on chenopod shrublands (refer text)
				3b: Other infrastructure	Concentrator and all other infrastructure	45	Grazing on pasture and shrublands	Grazing on chenopod shrublands

Table 17.3 Primary and secondary domains and final land use

Domain no.	Domain (primary)	Description of uses	Area (ha)	Secondary domain	Secondary domain description	Area (ha)	Pre-mining land use	Final land use
4	Nepean infrastructure area	Maintenance areas/workshops, truck load-out area, offices and amenities, top soil and other material stockpiles, internal road network and ancillary infrastructure	0.62	n/a	n/a	-	Grazing on pasture and shrublands	Grazing on chenopod shrublands Native woody vegetation
5	West Balranald access road	Access road and accommodation facility	72	n/a	n/a	-	Grazing on pasture and shrublands	Grazing on chenopod shrublands or access road left in place
6	Nepean access road	Access Road	15	n/a	n/a	-	Grazing on pasture and shrublands	Grazing on chenopod shrublands or access road left in place as may be negotiated with landolder. Native woody vegetation
7	Injection borefield	Access tracks and borefield infrastructure	1,435	7a:Access Roads and pipelines	n/a	220	Grazing on pasture and shrublands	Grazing on chenopod shrublands. Access road left in place as may be negotiated with landholder
				7b:Borefield infrastructure		1,215	Grazing on pasture and shrublands	Grazing on chenopod shrublands



Post-mining land use

Balranald Mineral Sands Project

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Figure 17.1

17.6 Rehabilitation methods for closure

Rehabilitation and decommissioning is expected to take a further two to five years following Year 9 of the operational phase.

17.6.1 Top soil and sub soil reinstatement, compaction and remediation

Upon decommissioning of infrastructure and hardstand areas at closure, compacted top soil and sub soil would be ripped under dry conditions to break up hard layers and provide a favourable root zone. These areas would be seeded with species appropriate to the identified post-mining land use. To alleviate any compaction that may have been caused by the movement of heavy machinery, all mined areas may be ripped to aid in reducing compaction of earth.

Subject to a mine specific evaluation, in areas of native vegetation rehabilitation, deep ripping may be implemented after the replacement of sub soil, but prior to replacement of the top soil.

Top soil and sub soil would be applied to landforms once they are re-contoured and drainage works are complete. Contour or diversion banks with stable discharge points would be constructed to limit slope lengths and control runoff. Collection drains and sedimentation dams would be installed to collect runoff and remove suspended sediment.

A number of matters would be addressed during the top soil and sub soil reinstatement. These are outlined in Section 4.1.2 of the RCS in Appendix M.

17.6.2 Drainage and erosion control

Restored surfaces would be stabilised as soon as practicable to reduce potential wind erosion and subsequent dust.

All rehabilitation areas and stockpiles would require stabilisation to protect them against the risk of erosion from wind or water. The most effective strategy for stabilisation would be trialled during the early stages of mining.

Drainage zones would not receive special erosion control treatments due to the infrequency of rainfall and subsequent flow events. If excessive sediment movement occurs then supplementary earthworks would be undertaken to return the drainage channels to design levels.

17.6.3 Control of surface water inflow to void

The control of surface water inflow into the final void would be directed away from the void batters through the construction of interceptor channel drains around the perimeter of the final void batters. Uncontrolled surface water has the potential to cause slope deterioration and ultimate failure.

17.6.4 Revegetation

Disturbed areas will be revegetated predominantly from the top soil seed store. Direct seedling, planted seedlings and transplanting of seedlings would be introduced into the revegetation program if considered necessary, after assessment of rehabilitation germination success.

Revegetation practices are expected to evolve over the life of the Balranald Project, as part of the process of continual improvement. If required, seedlings shall be propagated from seed, cuttings or tissue culture. The target species for nursery propagation, and method of planting would subject to ongoing trials.

Tube stock is expected to be used only in strategic landscape planting in certain domains where native woody vegetation is to be established.

Species selected would encourage the re-establishment of the pre-agricultural vegetation communities in those areas defined for woody vegetation establishment. Areas identified for shrublands and chenopod re-establishment would have stock excluded until it can be demonstrated that the vegetation is stable and self-sustaining, and that gazing would not impact upon its establishment.

17.6.5 Brush/timber spreading

Revegetation would include the spreading of brush and timber across the rehabilitated land, focussing on those areas where woody native vegetation is to be established. Subject to availability of material, the timber and or mulch would be spread thick enough to provide the desired benefits, but not so thick as to inhibit germination of seed.

Mulch would be spread following top soil replacement. Methods for spreading the understorey brush would be trialled and refined as rehabilitation progresses.

Larger stockpiled timber may also be utilised to develop fauna habitat piles.

17.7 Rehabilitation maintenance

Rehabilitated areas would be assessed against performance indicators and regularly inspected for key aspects outlined in Section 4.1.6 of the RCS in Appendix M. Where rehabilitation criteria have not been met, maintenance works would be undertaken.

17.7.1 Weed management

Weed management and mitigation measures to ensure rehabilitation and surrounding agricultural enterprises are successful would include:

- hosing down equipment in an approved wash down area before entry to the project area;
- herbicide spraying or scalping weeds from topsoil stockpiles prior to re-spreading topsoil;
- rehabilitation inspections to identify potential weed infestations; and
- identifying and spraying existing weed populations together with ongoing weed spraying over the life of the mine.

The spread of declared noxious weeds would be managed by using the measures above. Records would be maintained of weed infestations and control programs would be implemented according to industry best management practice for the weed species concerned.

17.7.2 Feral species management

A feral animal control strategy would be implemented to contain the spread of weeds and other detrimental impacts on rehabilitation areas by feral animals.

17.7.3 Infill planting and seeding

Rehabilitated areas may be planted and/or seeded opportunistically to take advantage of infrequent rainfall events. Monitoring of rehabilitation would identify any areas of low plant recruitment to be targeted for such supplementary planting and/or seeding programs.

17.7.4 Fire control

Developing vegetation within the revegetation areas would not be able to withstand fire for many years. Prior to the completion of mining, Iluka would consult with the appropriate agencies to ensure appropriate fire control strategies are developed.

17.7.5 Access

Access tracks would need to be required to facilitate the revegetation and ongoing maintenance of the mine. These tracks would be kept to a practical minimum and would be designated prior to the completion of mining in consultation with agencies.

17.7.6 Public Safety

Environmental management controls would be implemented in the project area to minimise the potential for impacts on public safety by the maintenance of fencing around those sections of the perimeter of the final void or any graded areas that have the potential to cause harm, that are accessible to the public.

17.8 Rehabilitation schedule

The progressive formation of the post-mining landform and the establishment of a vegetative cover would vary throughout the life of the Balranald Project, depending on the annual areas of disturbance and the availability of land for rehabilitation once mining activities have ceased.

17.9 Rehabilitation criteria

Rehabilitation criteria would be used as the basis for assessing when rehabilitation of the Balranald Project is complete.

The rehabilitation criteria would be subject to periodic formal review in consultation with relevant stakeholders. Amendments to the rehabilitation criteria would be subject to regulatory approval.

The rehabilitation criteria need to demonstrate that the rehabilitation objective has been achieved. Consequently, interim rehabilitation criteria are presented in Appendix M.

17.10 Rehabilitation monitoring

Regular monitoring of the rehabilitated areas would be required during the initial vegetation establishment period and beyond to demonstrate whether the objectives of the closure and rehabilitation strategy are being achieved and whether a sustainable and stable landform has been provided. Monitoring would be conducted periodically by suitably skilled and qualified persons at locations which would be representative of the range of conditions on the rehabilitating areas. Regular reviews of monitoring data would be undertaken to assess trends and monitoring program effectiveness.

Monitoring is proposed for different issue areas and is detailed in Section 5.2 of the RCS in Appendix M.

17.11 Conclusion

The RCS for the Balranald Project establishes clear and achievable objectives for the rehabilitation of land that will be disturbed due to the project. One key objective is that rehabilitation will aim to create a stable landform with the maximum possible post-mining land use capability and/or suitability. This will be achieved by setting clear rehabilitation success criteria and outlining the monitoring requirements that assess whether or not these criteria are being accomplished.

The Balranald Project will be progressively rehabilitated as mining operations move. Regular monitoring of the rehabilitated areas will be undertaken to demonstrate whether the objectives of the rehabilitation strategy are being achieved and whether a sustainable and stable landform has been achieved. The rehabilitation program will also be assessed against success criteria.

18 Traffic

18.1 Introduction

The SEARs require an assessment of potential traffic impacts due to the Balranald Project. The SEARs state that this EIS must include:

> accurate predictions of the road and rail traffic generated by the project;
>
> an assessment of the capacity of the rail network to accommodate the transport of ore;
>
> an assessment of potential traffic impacts on the safety and efficiency of the road network; and
>
> a detailed description of the measures that would be implemented to maintain and/or improve the capacity, efficiency and safety of the road and rail networks in the surrounding area over the life of the project.

The traffic assessment (TA) for the Balranald Project was prepared by EMM (Appendix N) and the results are summarised in this chapter.

The TA has been carried out with reference to the following standards, guidelines and policies:

- *Guide to Traffic Generating Developments* (RTA 2002); and
- *Guide to Road Design* (Austroads 2010).

It is noted that no rail infrastructure would be used by the Balranald Project in NSW, therefore rail impacts have not been addressed in this EIS.

18.2 Existing environment

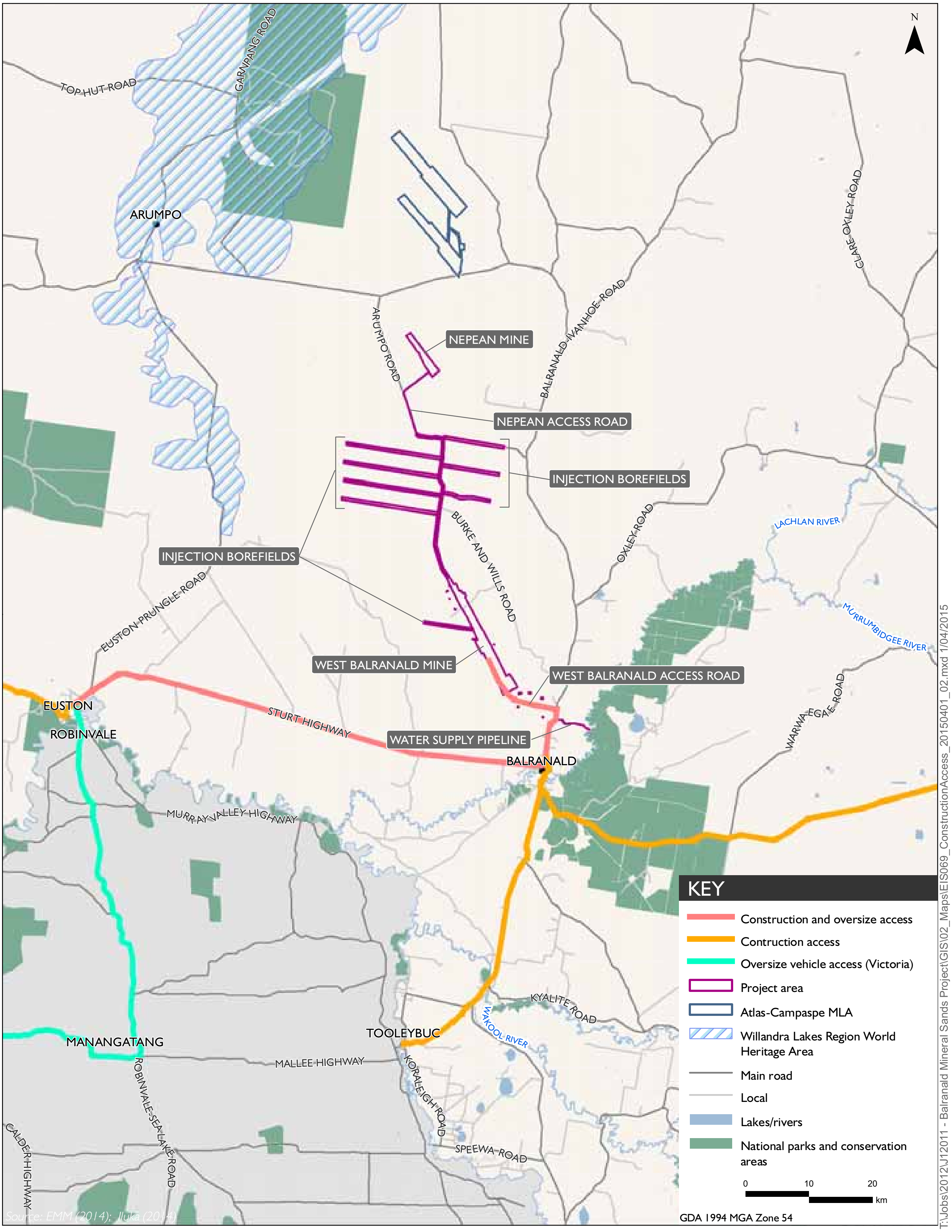
18.2.1 Local road network

A description of the road networks that would be used by the Balranald Project during construction and operational phases is provided in the following section and shown on Figure 18.1 and Figure 18.2.

i Balranald-Ivanhoe Road

Balranald-Ivanhoe Road is classified as a main road under local (BSC) jurisdiction. It runs for approximately 230 km from the Sturt Highway at Balranald town, generally in a northerly direction via Hatfield, to the Cobb Highway at Ivanhoe. The road has a 100 km/h speed limit outside Balranald town (north of Mungo and Moa streets). Mayall Street is the urban section of Balranald-Ivanhoe Road. This road is an approved B-Double route.

The sections of Balranald-Ivanhoe Road to the south of Burke and Wills Road that would be used by Balranald Project traffic has one lane in each direction, with no edge markings and no sealed shoulders.



EMM
ILUKA

Construction access routes

Balranald Mineral Sands Project
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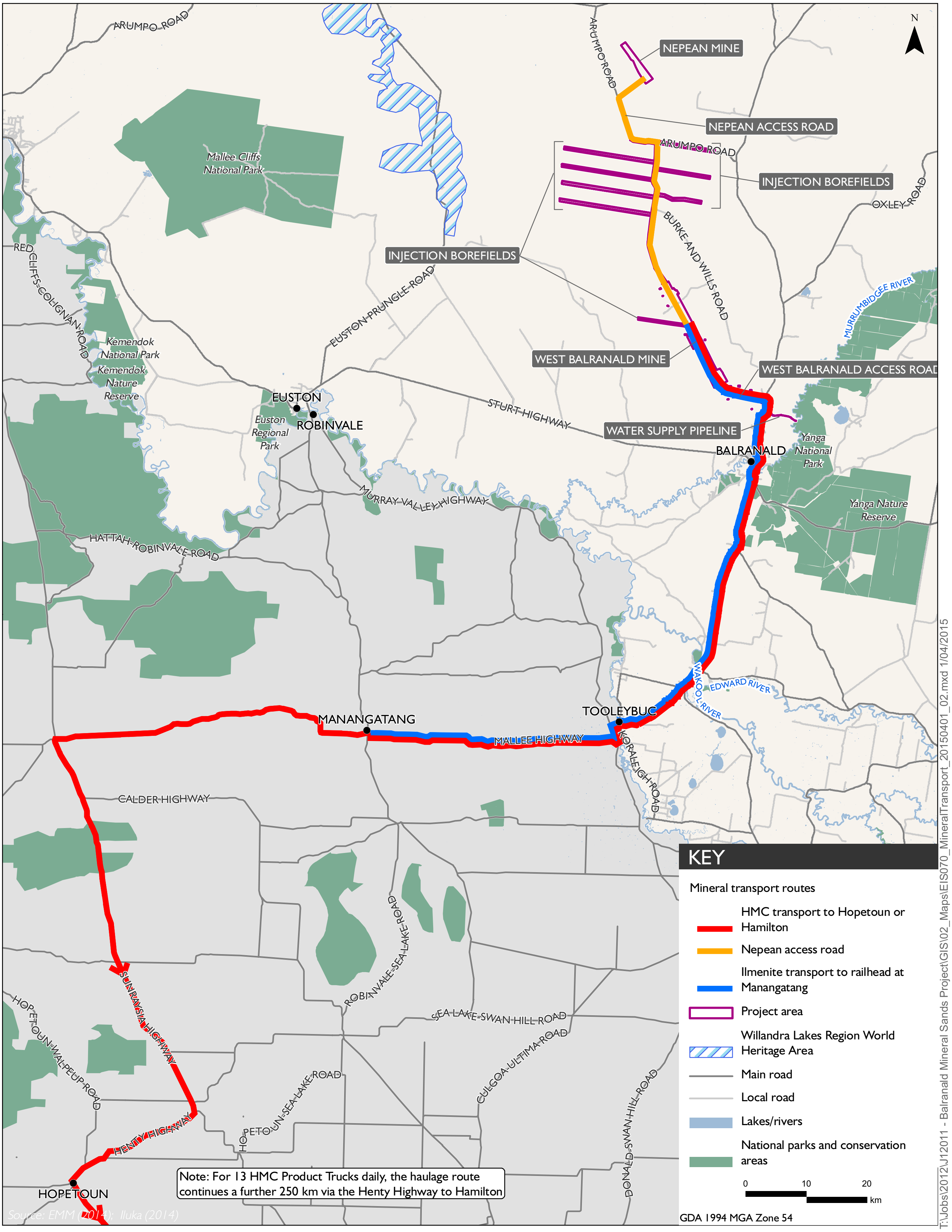
Figure 18.1



Proposed mineral transport routes

Balranald Mineral Sands Project
Environmental Impact Statement

Figure 18.2

EMM
ILUKA

ii Sturt Highway

The Sturt Highway is a highway under State (RMS) jurisdiction. It extends from the Hume Highway at Lower Tarcutta through Wagga Wagga, Narrandera, Hay, Balranald town, Euston and Buronga to the bridge over the Murray River at Mildura. This road is an approved B-Double route.

The Sturt Highway is known as Market Street within Balranald town. The Sturt Highway in the vicinity of Balranald has one lane in each direction with sealed shoulders, and is subject to a speed limit of 110 km/h outside Balranald town, reducing to 50 km/h along Market Street.

iii Balranald-Tooleybuc Road

The Balranald-Tooleybuc Road (also known as the Mallee Highway) is a main road under State (RMS) jurisdiction. It is the main traffic route between Balranald (NSW) and Piangil (Victoria). In NSW, it extends from the Sturt Highway, 2.8 km south of Balranald town, to the Tooleybuc Bridge at Tooleybuc. This road is an approved B-Double route and is subject to a speed limit of 100 km/h, reducing to 50 km/h within Tooleybuc.

iv Burke and Wills Road

Burke and Wills Road is located 15 km north of Balranald town and is under BSC jurisdiction. Burke and Wills Road extends from Balranald-Ivanhoe Road at its southern extent to Arumpo Road to the north. With the exception of the approach to its intersection with Balranald-Ivanhoe Road, the 46 km length of Burke and Wills Road is generally a formed un-sealed road, signposted as suitable for dry weather use only.

The road width varies, with two traffic lanes generally for the southern 22 km section and a single traffic lane generally for the remaining 24 km section to its intersection with Arumpo Road. There is a short sealed section commencing approximately 4 km from its intersection with Balranald-Ivanhoe Road where the road makes a sharp turn to the west. There is no sign posted speed limit for Burke and Wills Road, therefore a rural speed limit of 100 km/h applies.

v Arumpo Road

Arumpo Road is approximately 53 km north of Balranald town and is under BSC jurisdiction. It is an unsealed road from Balranald-Ivanhoe Road at its eastern extent to the Silver City Highway near Buronga to the west. Arumpo Road provides access to the Mungo National Park.

There is no sign posted speed limit for Arumpo Road, therefore a rural speed limit of 100 km/h applies.

vi Piper Street

Piper Street in Balranald town forms the western boundary of the town and runs from the Sturt Highway north to O'Connor Street. Piper Street is a local road under BSC jurisdiction. It has a narrow two lane seal with no road markings and vegetation growing along its shoulders. The road provides direct access to a mixture of residential and industrial properties. Between the Sturt Highway and O'Connor Street, this road is an approved B-Double route. A 50 km/hr urban speed limit applies to Piper Street.

vii Moa Street

Moa Street is a local road under BSC jurisdiction. It connects the Sturt Highway and Balranald-Ivanhoe Road. The road is two lanes wide with variable sealed width. It is wider towards the Sturt Highway at its southern extent and narrows towards Balranald-Ivanhoe Road. There are generally no road markings or sealed shoulders. This road is an approved B-Double route between the Sturt Highway and Balranald-Ivanhoe Road.

A 50 km/h urban speed limit applies to Moa Street south of O'Connor Street, and an 80 km/h limit applies between O'Connor Street and Balranald-Ivanhoe Road.

viii O'Connor Street

O'Connor Street is a local road under BSC jurisdiction that links Piper Street to Moa Street and comprises a narrow two lane wide seal with no road markings or sealed shoulders. The road provides access to the BSC maintenance depot, approximately mid-way along its length and is an approved B-Double route between Piper Street and Moa Street. A 50 km/h urban speed limit applies to O'Connor Street.

ix McCabe Street

McCabe Street is a local road under BSC jurisdiction. It runs from the Sturt Highway at its southern extent to Balranald-Ivanhoe Road to the north, to the east of Balranald town. It provides access to industrial areas located in the south-east of the town and the Balranald District Hospital.

The route is also used as a heavy vehicle bypass route for traffic travelling north or south from the Balranald-Ivanhoe Road and heading to and from destinations via the Sturt Highway and Balranald-Tooleybuc Road. McCabe Street is generally two lanes wide with no lane marking or sealed shoulders. The road is an approved B-Double route between the Sturt Highway and Balranald-Ivanhoe Road. An 80 km/h speed limit applies to McCabe Street.

18.2.2 Key intersections

Key intersections that would be used by traffic associated with the Balranald Project which have been assessed in the TA are:

- north of Balranald town:
  - Arumpo Road and Balranald-Ivanhoe Road;
  - Arumpo Road and Burke and Wills Road;
  - Burke and Wills Road and Balranald-Ivanhoe Road;
  - Balranald-Ivanhoe Road and the West Balranald access road (to be constructed as part of the Balranald Project);
- in Balranald town:
  - Balranald-Ivanhoe Road and Moa Street;
  - Balranald-Ivanhoe Road and McCabe Street;

- Balranald-Ivanhoe Road and Market Street (Sturt Highway);
- Sturt Highway and McCabe Street;
- Sturt Highway and Moa Street;
- Moa Street and O'Connor Street;
- Sturt Highway and Piper Street;

- west of Balranald town:
  - Sturt Highway and Murray Valley Highway (Euston);
- south of Balranald town to Tooleybuc:
  - Sturt Highway and Balranald-Tooleybuc Road;
  - Balranald-Tooleybuc Road and Kyalite Road;
  - Balranald-Tooleybuc Road and Swan Hill Road;
  - Balranald-Tooleybuc Road, Lockhart Road and Murray Street; and
  - Tooleybuc Bridge and Murray Street.

18.2.3 Traffic volumes

Traffic on the local roads in the immediate vicinity of the project area (Burke and Wills Road and Arumpo Road) is primarily local farm traffic, with some tourist traffic including campervans and vehicles towing caravans travelling to Mungo National Park. Closer to Balranald town, traffic is primarily local traffic on most roads with the exception of the Sturt Highway, Balranald-Ivanhoe Road, Moa Street and McCabe Street which are designated B-Double routes and carry significant proportions of heavy vehicle traffic.

Outside Balranald town, the major road network consists of the Sturt Highway, Balranald-Ivanhoe Road and Balranald-Tooleybuc Road. This network carries high proportions of heavy vehicle traffic, much of which is long distance or interstate freight traffic. Average annual daily traffic (AADT) volumes from the following sources were used to characterise existing traffic volumes:

- RMS traffic surveys and tube traffic counts (Aurecon 2015);
- RMS traffic counts for Balranald and Tooleybuc areas (2006) and RMS traffic surveys for Tooleybuc Bridge (2014);
- midday and daytime traffic usage of Burke and Wills Road and Arumpo Road observed by EMM (October 2014); and
- morning and afternoon peak hour traffic volumes for urban roads within Balranald town, including Moa Street, Piper Street, O'Connor Street and Mayall Street surveyed by EMM (October 2014).

The daily traffic volumes for key roads based on the sources listed above are in Table 18.1.

Table 18.1 Existing daily traffic and heavy vehicle volumes

Road	Survey year	Average daily traffic (all vehicles)	Average daily heavy vehicles	% Heavy vehicles
Balranald-Ivanhoe Road				
North of Oxley Road	2006	50	n/a	n/a
5 km north of Sturt Highway	2006	259	n/a	n/a
North of Moa Street	2014	418	99	24
North of Market Street in Balranald town	2014	710*	n/a	n/a
Sturt Highway				
Balranald, 1 km south of Balranald town	2014	1,476	496	34
Balranald, east of Balranald-Tooleybuc Road	2006	969	n/a	n/a
Euston, east of Murray Bridge Road	2006	1,215	n/a	n/a
Balranald-Tooleybuc Road				
Northern section	2014	559	135	24
Southern section	2014	385	92	24
At Tooleybuc Bridge	2014	991	180	18
Arumpo Road				
Western section	2014	30*	n/a	n/a
Eastern section	2014	20*	n/a	n/a
Burke and Wills Road				
Northern section	2014	10*	n/a	n/a
Southern section	2014	20*	n/a	n/a
McCabe Street (southern end)	2014	137	56	41
Piper Street (at Sturt Highway)	2014	70*	n/a	n/a
Moa Street (at Sturt Highway)	2014	360*	n/a	n/a
Moa Street (north of O'Connor Street)	2014	100*	n/a	n/a
O'Connor Street (west of Moa Street)	2014	120*	n/a	n/a

Source: *RMS and Aurecon daily traffic surveys and estimates for local roads determined from EMM hourly traffic counts.*

Notes: **Daily traffic volume is estimated from EMM hourly traffic volume surveys.*

n/a = No heavy vehicle information is available from the traffic surveys.

Outside Balranald town, the Sturt Highway, Balranald-Ivanhoe Road and Balranald-Tooleybuc Road carry relatively high proportions of heavy vehicle traffic (24–34%). On the local roads within and north of Balranald town, the volumes and proportions of heavy vehicle traffic are generally much lower, with the exception of McCabe Street which carries 41% heavy vehicles.

18.2.4 Traffic capacity standards – level of service

Daily and peak hourly traffic volume standards for major rural roads are set by the RMS's *Guide to Traffic Generating Developments* (RTA 2002) (the RMS guideline). The RMS guideline defines six levels of service (LoS) for rural roads, from LoS A through to LoS F.

On the Sturt Highway and the Balranald-Tooleybuc Road, current peak hourly traffic volumes are all generally below 120 vehicles per hour. These hourly volumes correspond to a LoS A or B. These levels of service correspond to:

- **LoS A:** The top level of service is a free flow condition in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high and the general level of comfort and convenience provided to traffic is excellent.

- **LoS B:** This level of service is termed stable flow and drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream, although the general level of comfort and convenience for traffic is a little less than that of LoS A.

On the Balranald–Ivanhoe Road and the local roads within Balranald town, the peak hourly traffic volumes are 100 vehicles per hour or less which also corresponds to LoS A. The exception is the section of the Sturt Highway (Market Street) through Balranald town, which has a higher peak hourly traffic volume, surveyed as 284 vehicles per hour on 30 October 2014, which corresponds to LoS B.

18.2.5 Existing pavement condition and width

Road width design standards for low volume (generally rural) roads are defined by the Austroads *Guide to Road Design* (Austroads 2010) and are based on daily traffic volumes.

The existing road pavement condition along the Balranald Project's proposed product transport route for HMC and ilmenite was assessed by visual inspections completed in accordance with best practice Austroads pavement survey guidelines. In NSW, the product haulage route includes Balranald-Ivanhoe Road, McCabe Street, Sturt Highway, Balranald-Tooleybuc Road and the Tooleybuc Bridge. The detailed pavement assessment methodology and results are presented in Appendix N.

Overall, the existing pavement condition was observed to be satisfactory with no visible major surface defects observed along approximately 90% of the total product transport route (in NSW). The extent of high severity surface deformations (eg rutting and corrugation) along the product transport route was more prevalent along the Balranald-Ivanhoe Road, McCabe Street and Sturt Highway sections of the proposed route. On Balranald-Tooleybuc Road, the observed extent of these defects was much more limited. However, varying degrees of pavement surface bleeding and texture loss were observed. The Tooleybuc Bridge was observed to have a very worn road pavement surface (Aurecon 2015). The existing road pavement sealed width is generally a minimum of 7 m on all sections of the product transport route within NSW (excluding McCabe Street and the Tooleybuc Bridge).

On other roads which are not part of the product transport route (Arumpo Road, Burke and Wills Road, the Balranald-Ivanhoe Road north of the West Balranald access road, Piper Street, Moa Street and O'Connor Street), the road sealed widths are generally less than 7 m. However, based on the current daily traffic usage for these roads the sealed widths are adequate for the existing traffic usage.

18.2.6 Traffic safety

A road safety audit was completed in 2012 for the product transport route (see Appendix D of the TA in Appendix N). A summary of the key recommendations of the road safety audit for existing traffic conditions and the anticipated future usage of the product transport route is presented in Section 18.4.

For the period 2009-2013, there were a total of 43 reported accidents recorded in the RMS database on the local roads used by the Balranald Project outside the Balranald town. Three fatal accidents occurred, two on the Sturt Highway on the rural section approximately 40–50 km west of Balranald town and one on Balranald-Tooleybuc Road approximately 10 km north-east of Tooleybuc. There was one reported traffic accident (injury accident) on the Balranald-Ivanhoe Road within approximately 100 km of Balranald town during the five year period. This accident occurred approximately 13 km north of Balranald.

18.2.7 Bus, pedestrian and cycling access

Intra and interstate public bus services operate through Balranald town on a regular basis. CountryLink operates a daily service between Cootamundra and Mildura which stops in Balranald town daily. Long distance bus services between Adelaide and Sydney are provided on weekdays by Greyhound Australia with east and westbound services to Adelaide stopping in Balranald town once daily. Balranald Community Transport Services (operated by the Far West Health Service) operates bus services between Balranald and Swan Hill (monthly) and Balranald to Mildura (fortnightly).

Due to the distances between the project area and Balranald town, which is a minimum of 10 km, local pedestrian or cycling access to the project area is considered highly unlikely.

18.3 Impact assessment

18.3.1 Construction

i Traffic generation

Construction of the mine is anticipated to take approximately 2.5 years. The peak project construction stage workforce would occur in 2018 and would include a combination of the later stage project construction workforce and some of the early project operational workforce.

The majority of the peak construction workforce on-site at this time (approximately 315 workers) would reside in the accommodation facility (approximately 95%, or 299 workers) and the remainder would commute (16 workers).

The workforce residing at the accommodation facility would generally travel by bus each day from the accommodation facility to within the project area. This would require some temporary use of the local road network during the initial phase of the construction period. Once the West Balranald mine access road is constructed, the majority of vehicle movements would be within the project area.

Other daily vehicle movements would include light vehicles from both the local and regional area, and drive in and drive out (DIDO) construction workforce travelling to/from the project area. The traffic generated by these movements is detailed in Table18.2.

Table 18.2 Peak construction workforce vehicle movements

Vehicle type	Origin/destination (% of movements)	Number of personnel	Assumed daily vehicle movements
Regional light vehicles	Balranald town/project area (80%) Euston, Robinvale/project area (10%) Swan Hill, Hay/project area (10%)	16	32
Local light vehicles	Locally based staff in and around Balranald (100%)	20	40
DIDO – light vehicles	Mildura, Euston, Robinvale/project area (70%) Hay/project area (15%) Swan Hill/project area (15%)	36	60 (based on 1.2 persons per car)
FIFO – bus	Mildura airport/project area (100%)	9	2
Total			**134**

For the purposes of assessing traffic impacts, it has been assumed that the peak workforce traffic movements (during both the construction and operational phases) generated at shift changeover times would coincide with the existing morning and afternoon peak traffic periods on the surrounding road network. It has also been assumed that 50% of the total daily workforce traffic movements would occur during each peak periods at affected intersections.

Heavy vehicle traffic generated during the construction phase is detailed in Table 18.3.

Table 18.3 Construction heavy vehicle movements

Type	Truck movements per day
Potable water supply, waste water transport, miscellaneous deliveries and waste removal primarily from the accommodation facility	36
Equipment, sand, soil, gravel, pipes, steelwork, concrete, mechanical and electrical components and pre-manufactured items	14
Over-dimensioned vehicle movements	4
Gravel supply during final two years of Balranald Project construction	116
Total	**170**

Over-dimensional vehicles would be used to move large plant and equipment from Iluka's WRP mine near Ouyen, Victoria, to the project area. It is anticipated that over dimensional vehicles would enter NSW from Robinvale in Victoria and would access the project area using the following roads:

- Sturt Highway from Euston/Robinvale;
- Piper Street;
- O'Connor Street;
- Moa Street; and
- Balranald-Ivanhoe Road.

It has been assumed that there would be approximately four over-dimensional vehicle movements per day from WRP mine to the project area during the later stages of project construction.

ii Traffic volumes

For the purposes of the TA, it was assumed that the peak construction phase occurs nominally in 2018, and background traffic has been assumed to have an annual growth rate of 2.5%. Therefore, daily traffic volumes surveyed in 2014 would have increased by approximately 10% by 2018 and daily traffic volumes surveyed in 2006 would have increased by around 30%.

Predicted traffic from the Atlas-Campaspe Mineral Sands Project (Resources Strategies 2012) has also been included, as it would also potentially contribute to higher traffic levels on the road network. The predicted traffic volumes on the surrounding round network including the Atlas-Campaspe Mineral Sands Project, Balranald Project and annual growth rate in 2018 are summarised in Table 18.4.

Daily traffic movements generated by the Balranald Project during the construction phase can be seen in Figure 18.3.

a. Roads

The primary construction access routes for the Balranald Project would include the Sturt Highway, Balranald-Ivanhoe Road and Balranald-Tooleybuc Road.

On sections of Balranald-Ivanhoe Road outside Balranald Town, the maximum project traffic usage would be approximately 304 daily vehicle movements. Traffic increases on the Sturt Highway due to the Balranald Project construction traffic would not be noticeable. Therefore, there would be no increase in the sealed road width required.

The combined future traffic usage in 2018 along sections of Balranald-Ivanhoe Road would be in the range 765–888 vehicle movements daily, and approximately 913 daily vehicle movements in the vicinity of Mayall Street in Balranald town. No widening or upgrading of intersections is required on Balranald-Ivanhoe Road.

In Balranald town, traffic volumes are predicted to increase on some roads through the town including McCabe Street and Market Street, while Moa Street, Piper Street and O'Connor Street would be used by over-dimensional vehicles. The following upgrades would be required to address the increase in traffic on roads in Balranald town:

- McCabe Street – provide sealed shoulders to increase in the road sealed width to a minimum of 7 m; and
- Piper Street, O'Connor Street and Moa Street – traffic management and minor intersection earthworks (eg fill) would be required to accommodate swept path for oversize vehicle movements.

Along the Balranald-Tooleybuc Road to Tooleybuc Bridge, daily traffic would increase by 12–32% for general traffic and 62–122% for heavy vehicle traffic. These predicted daily traffic increases would be noticeable however they are below the threshold for an increase in the road sealed width.

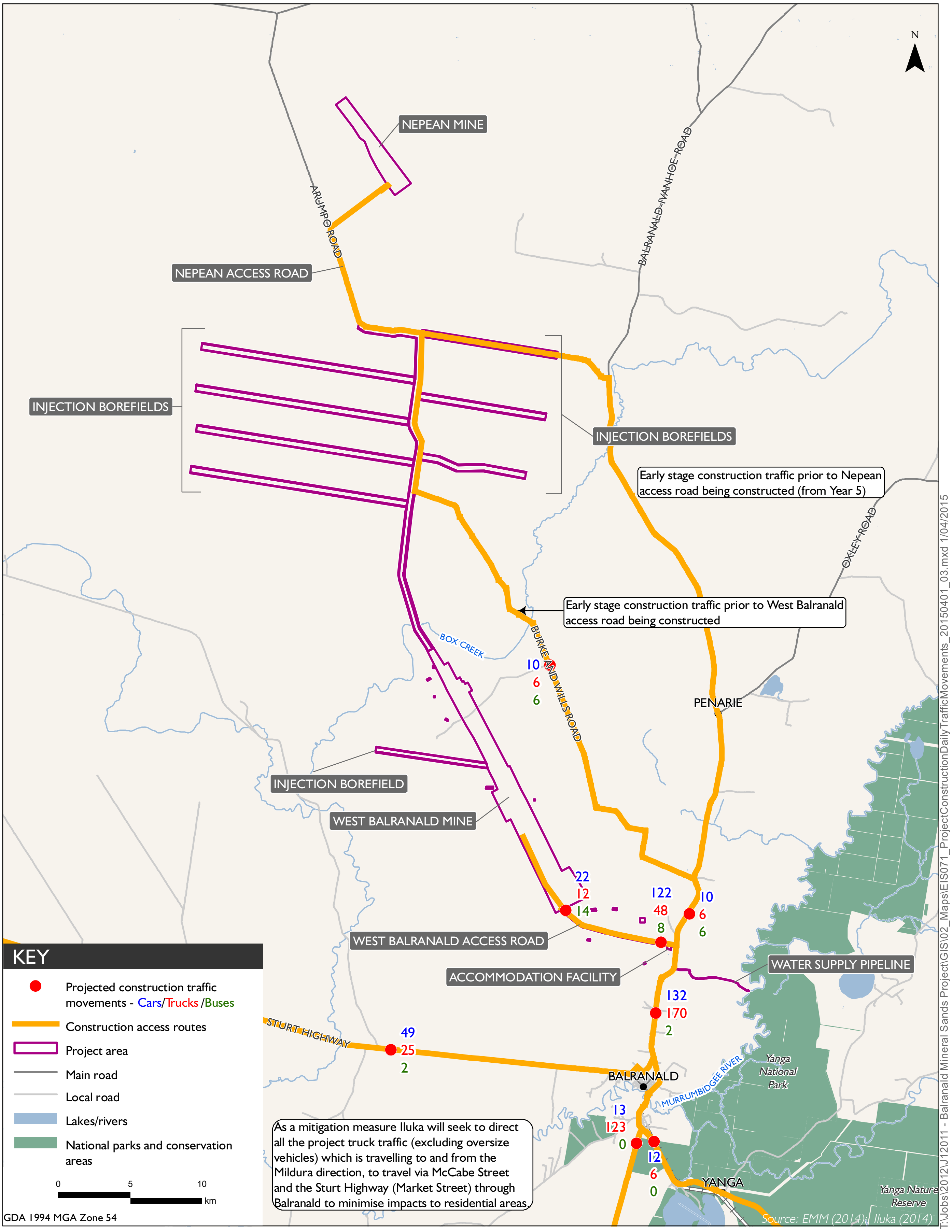
Burke and Wills Road would have combined future total daily traffic movements in the range 33–44 vehicle movements daily (or 111 – 122 daily vehicle movements during early stage construction prior to the construction of the West Balranald access road) which are both below the level where sealing of the road would be required.

Access routes to the project area can be seen in Figure 18.1.

Table 18.4 Daily construction traffic volume increase – 2018

Road name and location		Average daily traffic		Balranald Project daily traffic		Total daily traffic		Traffic increase (%)	
		All traffic	Heavy vehicles	All traffic	Heavy vehicles	All traffic	Heavy vehicles	All traffic	Heavy vehicles
Balranald-Ivanhoe Road	North of Oxley Road	179	24	0	0	179	24	0	0
	5 km north of Sturt Highway	451	92	304	172	765	264	70	187
	North of Moa Street	574	117	304	172	888	289	55	147
	North of Market Street in Balranald town	839	84	74	16	913	100	9	19
Sturt Highway	Balranald, 1 km south of Balranald town	1,628	548	154	129	1,782	677	9	24
	Balranald, east of Balranald-Tooleybuc Road	1,264	443	18	6	1,282	449	1	1
	Euston, east of Murray Bridge Road	1,634	553	76	27	1,710	580	5	5
Balranald-Tooleybuc Road	Northern section	615	149	136	123	751	272	22	83
	Southern section	424	101	136	123	560	224	32	122
	At Tooleybuc Bridge	1,090	198	136	123	1,226	321	12	62
Arumpo Road	Western section	33	3	0	0	33	3	0	0
	Eastern section	22	2	0	0	22	2	0	0
Burke and Wills Road	Northern section	11	1	22	12	33	13	200	1200
	Southern section	22	2	22	12	44	14	100	600
McCabe Street (southern end)		155	64	154	129	309	193	99	201
Piper Street (at Sturt Highway)		77	8	25	25*	102	33	32	313*
Moa Street (at Sturt Highway		450	20	51	2*	501	22	11	10*
Moa Street (north of O'Connor Street)		165	11	76	27*	241	38	46	245*
O'Connor Street (west of Moa Street)		132	13	25	25*	157	38	19	192*
Market Street Sturt Highway (west of Mayall Street)		3,250	600	24	6	3,274	606	1	1

Note: * as a mitigation measure Iluka would seek to redirect the majority of heavy vehicles travelling from Mildura to use the McCabe Street bypass to minimise impacts to these residential areas.



Proposed construction daily traffic movements

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Figure 18.3

b. Intersections

Key intersections used for the Balranald Project are listed in Section 18.2.2. All intersections currently do not exceed the threshold required for left turn or right turn lanes. However, due to oversize construction vehicle movements accessing the West Balranald access road with the Balranald-Ivanhoe Road, some widening of the Balranald-Ivanhoe Road would be required at this intersection.

The peak hour traffic conditions at the predominantly rural intersections along the product transport route south from Balranald town, including sections of the Sturt Highway and the Balranald-Tooleybuc Road have been assessed with the addition of the project construction traffic, the future peak hourly traffic volumes at these intersection would not increase to the extent that any additional intersection turning lanes would be required. A SIDRA analysis of the Tooleybuc Bridge and Murray Street intersection was undertaken.

Peak hourly traffic conditions at key intersections in Balranald town were assessed. A SIDRA analysis was completed for the Mayall Street with Sturt Highway intersection as it was considered that it is the most heavily trafficked in Balranald town and therefore represented a worst case scenario. The analysis found that the intersection operated at a LoS A for all scenarios. It was determined that a SIDRA analysis of other intersections in Balranald town wasn't required. However, a number of intersection improvements were identified in the road safety audit and are detailed in Section 18.4.

This intersection was considered to be worst case scenario for rural intersections on the product transport route. The LoS was found to be A in 2014 and B in 2018 due to traffic growth. These levels of service do not warrant major intersection improvements.

A SIDRA analysis of other rural and urban intersections was not considered to be warranted.

iii Traffic safety

A number of proposed road safety and pavement recommendations during the Balranald Project construction phase that Iluka would be implementing are outlined in Section 18.4.

iv Road pavement and maintenance

For the product transport route, a detailed visual pavement condition assessment (Aurecon 2015) has been completed with defects logged by type, severity and location using Austroads guidelines. A number of short term management measures are outlined in Section 18.4.

v Parking, public transport and pedestrian access

Construction phase car parking areas would be provided to meet demand at all identified Balranald Project worksites and at the accommodation facility.

No public transport improvements are required for the constructions phase. Extensive use of private bus transport is envisaged for construction workforce travel between the accommodation facility and construction worksites.

Due to the remote nature of the project area, access by the workforce using either cycling or walking is not envisaged.

18.3.2 Operations

i Traffic generation

The peak workforce during the operational phase would be approximately 385 persons on-site at any point in time. It has been assumed for this assessment that, of these, approximately 366 persons would reside at the accommodation facility and 19 may commute on a daily basis.

The majority of the operational workforce residing at the accommodation facility in the project area would travel via buses within the project area. Minimal traffic movements on the public road network would be generated. A total of 63 people would travel via light vehicles (19 from both the local and regional area and 44 DIDO) to and from shifts daily. The traffic generated by these movements is detailed in Table 18.5. The same assumptions made for the construction workforce distributions in Table 18.2 were applied to the operational vehicle traffic distributions.

Table 18.5 Operational workforce vehicle movements

Type of vehicle	Number of personnel	Assumed daily vehicle movements
Regional light vehicles	19	38
Local light vehicles	20	40
DIDO	44	74 (based on 1.2 persons per car)
FIFO	11	2
Total		**154**

Traffic generated by the delivery of mine supplies, consumables, waste removal and other miscellaneous deliveries is summarised in Table 18.6.

Table 18.6 Bulk commodities generated vehicle movements

Commodity	Daily vehicle movements
Hydrated lime	2
Diesel	6
Limestone	6
Potable water supply and waste water transport	16
Miscellaneous deliveries and waste removal	20
Gravel	Included as backloaded with product haulage
Total	**50**

Of the movements in Table 18.6, it has been assumed that 16 movements per day would be generated to and from Balranald town. The remainder would be to and from other regional destinations.

The majority of HMC produced would be trucked by B-double (in bulk) to Iluka's existing rail loading facility in Hopetoun, Victoria[3]. Ilmenite would be transported to a proposed rail loading facility at Manangatang, Victoria. The transport of ilmenite would be by either B-double (in bulk) or containerised on flat-bed trucks. HMC and ilmenite would be transported via Balranald-Ivanhoe Road, McCabe Street, Sturt Highway, Balranald-Tooleybuc Road and then west into Victoria via Tooleybuc. Up to 75 B-Double trucks (150 movements) transporting HMC (70 movements) and ilmenite (80 movements) would be generated daily. Of these, approximately 71 trucks would return each day back-loaded with either gravel (58 trucks per day) or mining by-products from the Hamilton MSP (13 trucks per day). Four scenarios have been assessed in the TA with respect to pavement condition, however the worst case scenario (ie 150 movements per day) has been assessed for impacts to traffic and intersections (refer to Section 6.5 of Appendix N).

The transport of ore from Nepean mine to the West Balranald mine would be via the Nepean access road. This would occur from approximately Year 6 to Year 8 of the operational phase. The transport of ore would require registered vehicles as part of the route uses public roads. Transport of ore from the Nepean mine would generate approximately one truck every six minutes travelling in each direction, approximately 500 daily truck movements in total during mining at the Nepean mine.

ii Traffic volumes

To assess traffic impacts, it has been assumed that the peak operational phase occurs in 2020 and background traffic has been assumed to have an annual growth rate of 2.5%. Therefore, daily traffic volumes surveyed in 2014 would have increased by approximately 15% by 2020 and daily traffic volumes surveyed in 2006 would have increased by around 35%.

Predicted traffic from the Atlas-Campaspe Mineral Sands Project (Resource Strategies 2012) has also been included, as it would potentially contribute to higher traffic levels on the road network. The predicted traffic volumes on the surrounding round network including the Atlas-Campaspe Mineral Sands Project, Balranald Project and annual growth rate in 2020 are summarised in Table 18.7.

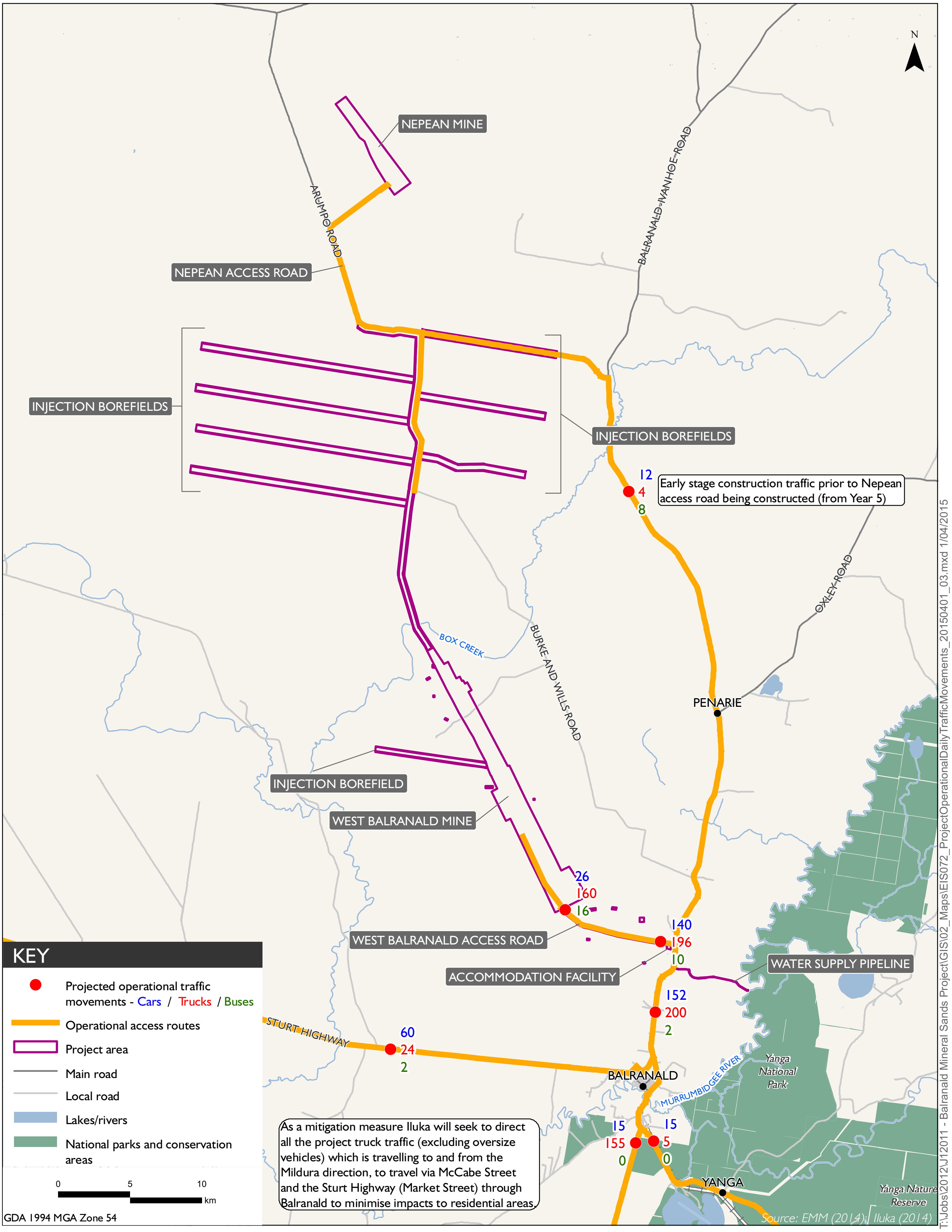
Daily traffic movements generated by the Balranald Project during the operational phase can be seen in Figure 18.4.

[3] Up to 13 trucks per day would transport HMC from the project area to Iluka's Hamilton MSP to enable mining by-products to be backloaded for disposal into the West Balranald mine void.

Table 18.7 Daily operational phase traffic increase – 2020

Road name and location		Average daily traffic		Balranald Project daily traffic		Total daily traffic		Traffic increase (%)	
		All traffic	Heavy vehicles	All traffic	Heavy vehicles	All traffic	Heavy vehicles	All traffic	Heavy vehicles
Balranald-Ivanhoe Road	North of Oxley Road	162	25	24	12	186	37	15	48
	5 km north of Sturt Highway	444	96	354	202	798	298	80	210
	North of Moa Street	575	122	354	202	929	324	62	166
	North of Market Street in Balranald town	878	88	78	16	956	104	9	18
Sturt Highway	Balranald, 1 km south of Balranald town	1,703	572	190	160	1,893	732	11	28
	Balranald, east of Balranald-Tooleybuc Road	1,314	460	20	5	1,334	465	2	1
	Euston, east of Murray Bridge Road	1,667	574	86	26	1,753	600	5	5
Balranald-Tooleybuc Road	Northern section	643	155	170	155	813	310	26	100
	Southern section	443	106	170	155	613	261	38	146
	At Tooleybuc Bridge	1,140	207	170	155	1,310	362	15	75
Arumpo Road	Western section	35	4	24	12	59	16	69	300
	Eastern section	23	2	24	12	47	14	104	600
Burke and Wills Road	Northern section	12	1	0	0	12	1	0	0
	Southern section	23	2	0	0	23	2	0	0
McCabe Street (southern end)		164	66	190	160	354	226	116	242
Piper Street (at Sturt Highway)		81	8	24	24*	105	32	30	300*
Moa Street (at Sturt Highway		441	21	62	2*	503	23	14	10*
Moa Street (north of O'Connor Street)		142	12	86	26*	228	38	61	217*
O'Connor Street (west of Moa Street)		138	14	24	24*	162	38	17	171*
Market Street Sturt Highway (west of Mayall Street)		3,375	625	26	5	3,401	630	1	1

Notes: **as a mitigation measure Iluka would seek to redirect the majority of heavy vehicles travelling from Mildura to use the McCabe Street bypass to minimise impacts to these residential areas.*



Project operational daily traffic movements
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Figure 18.4

a. Roads

On the local project area access routes, primarily the eastern section of Arumpo Road, the maximum predicted daily traffic (not associated with transport of ore) would be approximately 24 vehicle movements. The combined future total daily traffic movements on this section would be in the range of 47–59 vehicle movements daily, which is well below the level where sealing of the road would be recommended.

The northern section of Burke and Wills Road and the western section of Arumpo Road (west of the intersection with Burke and Wills Road) would be upgraded as part of the Nepean access road to accommodate the transport of ore during Year 6 to Year 8. The upgrade would not be required until the commencement of Nepean mine (Year 6) as these road sections would not be used by significant additional mine traffic until that time.

Along sections of Balranald-Ivanhoe Road outside Balranald town, (ie between Moa Street and the West Balranald access road intersection), the maximum project traffic usage would be approximately 354 daily vehicle movements. The Balranald Project traffic using Balranald-Ivanhoe Road south of the West Balranald access road, would result in a 62–80% increase to the future daily traffic and a 166–210% increase in the heavy vehicle traffic volume. The combined traffic volume would be in the range 798 to 929 daily vehicle movements. This is below the level where widening of the existing 7.0 m road sealed width would be required. On the sections of Balranald-Ivanhoe Road closer to the town centre (Mayall Street), there would be approximately 956 daily vehicle movements. No widening or upgrading of intersections is required on Balranald-Ivanhoe Road.

Traffic increases on the Sturt Highway and Balranald-Tooleybuc Road to Tooleybuc Bridge due to the Balranald Project operational traffic would not require increases in the sealed road width.

Access routes to the project area during the operational phase can be seen in Figure 18.1.

b. Intersections

At key intersections used for the Balranald Project, listed in Section 18.2.2, the current traffic volumes do not exceed the threshold required for left turn or right turn lanes. However, at the Burke and Wills Road and Arumpo Road intersection, where both roads are currently unsealed, both intersection approaches should be sealed for at least 50 and 100 m respectively. Additionally, at the new West Balranald access road intersection with Balranald-Ivanhoe Road, widening of the major road is required to provide a left turning traffic lane, for use by decelerating trucks (primarily to and from the south).

The peak hour traffic conditions at the predominantly rural intersections along the product transport route south from Balranald, including sections of the Sturt Highway south of Balranald and the Balranald-Tooleybuc Road have been assessed. With the addition of the project operational traffic, the future peak hourly traffic volumes at these intersections would not increase to the extent that any additional intersection turning lanes would be required. A SIDRA analysis of the Tooleybuc Bridge and Murray Street intersection was undertaken.

Peak hourly traffic conditions at key intersections in Balranald town were assessed. It was considered that the Mayall Street with Sturt Highway intersection was the most heavily trafficked in Balranald town and therefore represented a worst case scenario. A SIDRA analysis was completed and it was found to operate at a LoS A for all scenarios. It was determined that a SIDRA analysis of other intersections in Balranald town was not required.

The LoS in 2014 afternoon and morning peak hour was A. However, by 2020 with increased traffic growth, it would decline to LoS B. These levels of service do not warrant major intersection improvements. This intersection was considered the worst case for intersections on the product transport route and therefore no further intersection assessments were required.

iii Traffic safety

A number of safety and road pavement recommendations that Iluka would implement to maintain traffic safety are outlined in Section 18.4.

iv Road pavement and maintenance

Road pavements impacts would primarily be due to product haulage and associated backloading on the proposed product transport route, although impacts would also occur to local mine access routes.

Medium to long term maintenance strategies and responsibilities for road pavement management are presented in Appendix N.

v Parking, public transport and pedestrian access

Operation phase car parking areas would be provided to meet demand at all identified Balranald Project worksites and the accommodation facility.

Public transport mine access is not required for the Balranald Project operational phase. Extensive use of shuttle bus transport is envisaged for project operations workforce travel between the accommodation facility and worksites within the project area, plus a shuttle bus service to and from the airport at Mildura for FIFO workers.

Due to the remote nature of the project area, access by the workforce using either cycling or walking is not envisaged.

18.4 Management and mitigation

18.4.1 Improvements to be implemented by Iluka

Proposed road safety, intersection improvements and pavement maintenance that would be implemented by Iluka to mitigate the impacts of Balranald Project-related traffic are provided in Table 18.8.

Table 18.8 Summary of proposed road and intersection improvements

Balranald Project phase	Proposed improvement
Burke and Wills Road	
Construction	• Iluka would ensure a minimum 8 m wide two lane unsealed road is maintained on all sections required for Balranald Project construction access with sections regraded to address induced damage (eg corrugations, potholes and other surface defects).
Operation	• Prior to the start of Nepean mine operations, the 12 km section of the road forming part of the Nepean access road would be improved to a minimum width of 11 m (formation width of 11 m including 1.5 m wide shoulders), but would remain unsealed. • Iluka would install signage east of the Nepean access road intersection with Burke and Wills Road (34 km north-west of Balranald-Ivanhoe Road) and south of Arumpo Road at the Burke and Wills Road intersection alerting road users to the presence of haulage trucks. • This section would be regraded during the operational phase to address induced damage (eg corrugations, potholes and other surface defects). • Alternatively, the unsealed road width could be reduced to 8 m with the implementation of additional traffic management measures. This would involve clearly signposting the alternative (mainly sealed) travel route via Arumpo Road, for Lake Mungo tourist traffic and other non-local traffic. The speed limit would be reduced to 80 km/hr in consultation with BSC to minimise potential traffic safety conflicts between operational phase traffic and other non-mining traffic using the road.
Arumpo Road	
Operations	• Approximately 10 km of Arumpo Road west of the Burke and Wills Road intersection would from part of the Nepean access road. • This 10 km section of Arumpo Road (west of the Burke and Wills Road) that forms part of the Nepean access road would be improved prior to the start of Nepean mine operations to be a minimum of 11 m wide (formation width of 11 m including 1.5 m wide shoulders). • Iluka would install signage west of the actual Nepean mine access intersection (10 km north-west of Burke and Wills Road) and east of the Burke and Wills Road intersection alerting road users to the presence of product haulage trucks. • This section would be regraded during the operational phase to address induced damage (eg corrugations, potholes and other surface defects). • Advance and intersection direction signage would be provided at the Arumpo Road/Burke and Wills Road intersection for traffic approaching from the west (ie from the Lake Mungo direction). This would advise tourist traffic travelling towards Balranald to travel via Arumpo Road rather than Burke and Wills Road. It would indicate that, if travelling to Balranald, there is 10 km of unsealed road on Arumpo Road and 46 km of unsealed road on Burke and Wills Road.
Balranald-Ivanhoe Road	
Construction and operations	• Route signage, line marking and guide post deficiencies identified in the RSA would be rectified by Iluka during the construction phase. • A road maintenance contribution to BSC (based on tonnes of product transported) would be negotiated prior to the Balranald Project operations phase. This would be used by BSC for maintenance of this section of the product transport route.
McCabe Street	
Construction and operations	• A requirement to provide sealed shoulders to provide a minimum road sealed width of 7 m would be addressed by Iluka through road maintenance contributions to BSC in the Balranald Project construction phase. • An existing requirement to resurface the asphalt layer identified in the Road Pavement Strength Review would be addressed by Iluka directly or through road maintenance contributions to BSC in the Balranald Project operations phase. • Undertaking asphalt upgrade would reduce ongoing pavement maintenance contribution to BSC (based on tonnes of product transported) along McCabe Street.

Table 18.8 Summary of proposed road and intersection improvements

Balranald Project phase	Proposed improvement
Balranald-Ivanhoe Road and West Balranald access road intersection	
Construction and operations	• A new Balranald-Ivanhoe Road/West Balranald access road intersection, designed in accordance with the Austroads intersection design standard, would be constructed by Iluka. It would incorporate a left turn deceleration lane to facilitate heavy vehicle movements (primarily to and from the south) at the intersection. • The intersection sight distance would be a minimum of 450 m in both directions along Balranald-Ivanhoe Road. • Advance and position intersection signs would be provided for the approaching traffic on Balranald-Ivanhoe Road in both directions.
Intersections of Balranald-Ivanhoe Road and Moa Street, Moa Street and O'Connor Street, Piper Street and O'Connor Street, and Sturt Highway and Piper Street	
Construction and operations	• Iluka would seek to redirect the majority of heavy vehicles travelling from Mildura to use the Sturt Highway and McCabe Street bypass to minimise potential impacts to residential areas during the construction and operations phases. • Traffic management and additional intersection earthworks (eg fill) would be provided by Iluka to accommodate the turning 'swept paths' for over dimensional vehicles as determined by Aurecon's (2012) assessment. This temporary improvement would also facilitate the use of this intersection by other Balranald Project-related construction, including B-Double type trucks.
Sturt Highway and Murray Valley Highway intersection near Euston/Robinvale	
Construction	• Traffic management and additional intersection earthworks (eg fill) would be provided by Iluka to accommodate the turning 'swept paths' for over dimensional as determined by Aurecon's (2012) assessment. This temporary improvement would also facilitate the use of this intersection by other Balranald Project-related construction traffic, including B-Double type trucks.
Balranald-Ivanhoe Road and McCabe Street intersection	
Operations	• Iluka would formalise the existing left turn deceleration lane, designed in accordance with the Austroads intersection design standard, by providing line marking for the lane prior to the start of the Balranald Project operational phase. • Visual barriers and/or landscaping would be provided by Iluka prior to the start of the Balranald Project operational phase to remove the RSA identified 'see through effect' between the Balranald Road (north) and McCabe Street approaches.
McCabe Street and Sturt Highway intersection	
Operations	• Signage and/or vegetation within the road reserve of the Sturt Highway currently blocks sight lines of approaching traffic on the Sturt Highway at the McCabe Street and Sturt Highway intersection. • Iluka, in consultation with RMS, would rectify by vegetation removal and adjustments to the height of signage, to provide clear sight lines for car and truck drivers who are travelling on the McCabe Street (north) and Sturt Highway (south) approaches to the intersection.
Arumpo Road and Burke and Wills Road intersection	
Operations	• Iluka would seal the three intersection approaches, for at least 100 m on the two Arumpo Road approaches and at least 50 m on the Burke and Wills Road approach. This would improve the intersection traffic operations, visibility (by reducing dust) and traffic safety during the operation of the Nepean mine.

18.4.2 Improvements to be implemented by road authorities

The TA identified that a number of other road safety improvements would be required, either currently or by the years 2018 or 2020 (ie regardless of whether the Balranald Project was to proceed), at several locations either due to existing road construction or projected background traffic growth. It is envisaged that these improvements would generally be implemented by the responsible road authority for each route. These improvements are described in Section 7.1.2 of the TA (refer Appendix N).

18.4.3 Traffic management plan

A traffic management plan would be prepared for the Balranald Project and would describe measures to:

- maximise safety for all light and heavy vehicle operations related to the Balranald Project;
- ensure compliance with the state and Commonwealth road transport legislative and regulatory requirements;
- manage driver fatigue; and
- respond to any product haulage incident or emergency.

18.5 Conclusion

The highest traffic generation associated with the construction of the Balranald Project would occur on Balranald-Ivanhoe Road. At this location, a peak of approximately 304 additional movements per day is anticipated. This traffic generation is not anticipated to have a material impact upon the capacity and performance of the local road network.

During operations, the Balranald Project is predicted to generate a maximum of approximately 354 vehicle movements per day on the Balranald-Ivanhoe Road. Similar to construction traffic, the anticipated additional traffic movements during operation would have no material impact on the road network.

The proposed road and intersection improvements in Table 18.8 would address the identified traffic safety, level of service, road pavement and maintenance impacts from the Balranald Project traffic during the construction and operational phases. This would include negotiating an equitable road maintenance agreement with the BSC to proportionally fund the ongoing maintenance requirements for the council roads affected along the product haulage route.

Overall, it is expected that with the proposed mitigation and management measures, the Balranald Project is unlikely to have a material impact on the existing road network.

19 Social

19.1 Introduction

The SEARs for the Balranald Project state that this EIS must include:

> an assessment of the likely social impacts of the development (including perceived impacts), paying particular attention to any impacts on Balranald; and

A social assessment for the Balranald Project was prepared by EMM (Appendix O). It is based on a substantial body of work undertaken by consultancy Environmental Affairs Pty Ltd for the Balranald Project, which included gathering the majority of the baseline data used in this report, including documenting the relevant policy context, developing a profile of the Balranald community and documenting the results of engagement with relevant stakeholders.

The social assessment considered a number of policies at the Commonwealth, State, regional and local levels. These included:

- *Techniques for Effective Social Impact Assessment: A Practical Guide* (Office of Social Policy, NSW Government Social Policy Directorate);
- *Strengthening Basin Communities* (Commonwealth Government 2009);
- the Basin Plan (MDBA 2012);
- *NSW 2021: A Plan to Make NSW Number One* (NSW Government 2011);
- Mining SEPP;
- Murray-Lower Darling Regional Action Plan (NSW Government 2012);
- *Murray Regional Plan NSW 2010-2015* (Regional Development Australia [RDA] Murray 2010);
- *Balranald Shire Community Strategic Plan 'Balranald Shire 2022'* (Balranald Shire Council 2012);
- *Strengthening Basin Communities - Community Development Plans for Balranald and Euston 2012-16* (Balranald Shire Council 2012);
- *Balranald Shire Economic Development Strategy (Western Cluster) 2011-16* (Balranald Shire Council 2011); and
- *Draft Balranald Crime Prevention Plan 2011-15* (Balranald Shire Council 2011).

The results of the social assessment are summarised in this chapter.

19.2 Existing environment

The Balranald LGA is in the Murray region of south-western NSW, approximately 850 km south-west of Sydney and 450 km north of Melbourne. It is the fifth largest LGA in NSW, covering 21,400 km^2 but represents less than 0.1% of the NSW population (2,283 persons as at the 2011 Census of Population and Housing (the Census)).

The main urban centres in Balranald LGA are Balranald town (1,159 persons), located on the Murrumbidgee River, and Euston (600 persons), located on the Murray River near Robinvale.

The primary assessment area is Balranald town. The boundary of Balranald town aligns with the Australian Bureau of Statistics (ABS) 2011 Census of Population and Housing (2011 Census) Balranald Urban Centres and Localities (UCLs) boundary. This primary area was determined given its proximity to the project area. Notwithstanding this, it should be noted that while Balranald town is the primary assessment area, the Balranald community is generally considered to extend beyond the town of Balranald. The physical extent of the Balranald community varies according to the basis of definition, for example, school catchment areas or source of sporting team participants. As such, a secondary assessment area is the Balranald LGA.

The study area for the social assessment can be seen in Figure 19.1.

The Sturt Highway is the main transport route into and through the Balranald LGA, creating important linkages into Victoria and South Australia. The proximity of the Murrumbidgee River has historically influenced the economy of the Balranald LGA, which is largely based on agriculture, including grains (dryland and irrigated), sheep and cattle. Economic diversification into horticulture, viticulture, organic agriculture, forestry and tourism industries has recently occurred in the area (Sinclair Knight Merz 2010).

19.2.1 Key socio-economic characteristics

Key socio-economic characteristics from the 2011 Census for Balranald town and Balranald LGA, as well as for non-metropolitan NSW and NSW overall, are in Table 19.1 and summarised below.

It should be noted that there were changes to Australian Bureau of Statistics (ABS) collection catchments between the 2006 and 2011 censuses. This resulted in a small increase in the catchment area of Balranald town between 2006 and 2011.

Table 19.1 Key socio-economic characteristics

Characteristic	Balranald town[1]	Balranald LGA	Non-metropolitan NSW	NSW
Population 2011 (persons)	1,159	2,283	2,512,949	6,917,660
Population 2006 (persons)	1,216	2,441	2,419,815	6,549,178
Population growth (2006-2011) (%)	-4.7	-6.5	3.8	5.6
Annual rate of population growth 2006-2011 (%)	-1%	-1.3	0.8	1.1
Forecast population growth[2] 2011-2036 (%)	N/A	-0.7	1.0	1.6
Male population 2011 (persons and %)	589 (50.8)	1,175 (51.5)	-	3,408,878 (49%)

Table 19.1 Key socio-economic characteristics

Characteristic	Balranald town[1]	Balranald LGA	Non-metropolitan NSW	NSW
Female population 2011 (persons and %)	570 (49.2)	1,108 (48.5)	-	3,508,780 (50.7)
Indigenous population 2011 (persons and %)	100 (8.6)	155 (6.8)	115,596 (4.6)	172,621 (2.5)
Younger age 0 to 4 years 2011 (%)	6.4	7.3	6.3	6.6
Working age[3] 15 to 64 years 2011 (%)	61.5	63.9	62.5	66.0
People aged 65+ years 2011 (%)	20.3	15.6	18.0	14.7
Median age 2011 (years)	44	41	41	38
Unemployment Sep 2014[4](%)	Not available at the UCL level	5.0	-	5.7
Industry structure 2011 (largest categories)	Health care and social assistance, agriculture/forestry/ fishing, retail trade	Agriculture/forestry/ fishing, health care and social assistance, accommodation and food services	Health care/social assistance, retail trade, education and training and manufacturing	Health care/social assistance, retail trade, manufacturing, and professional scientific and technical services
Occupational structure 2011 (largest categories)	Labourers, machinery operators and drivers, managers, and community personal services	Managers, labourers, technicians/trade workers and clerical/administrative workers	Professionals, technicians/ trades, managers, and clerical/administrative workers	Professionals, clerical/administrative workers, and technicians/trades
Average household size 2011 (persons)	2.3	2.4	2.4	2.6
Average weekly household income 2011 ($)	838	894	961	1,237

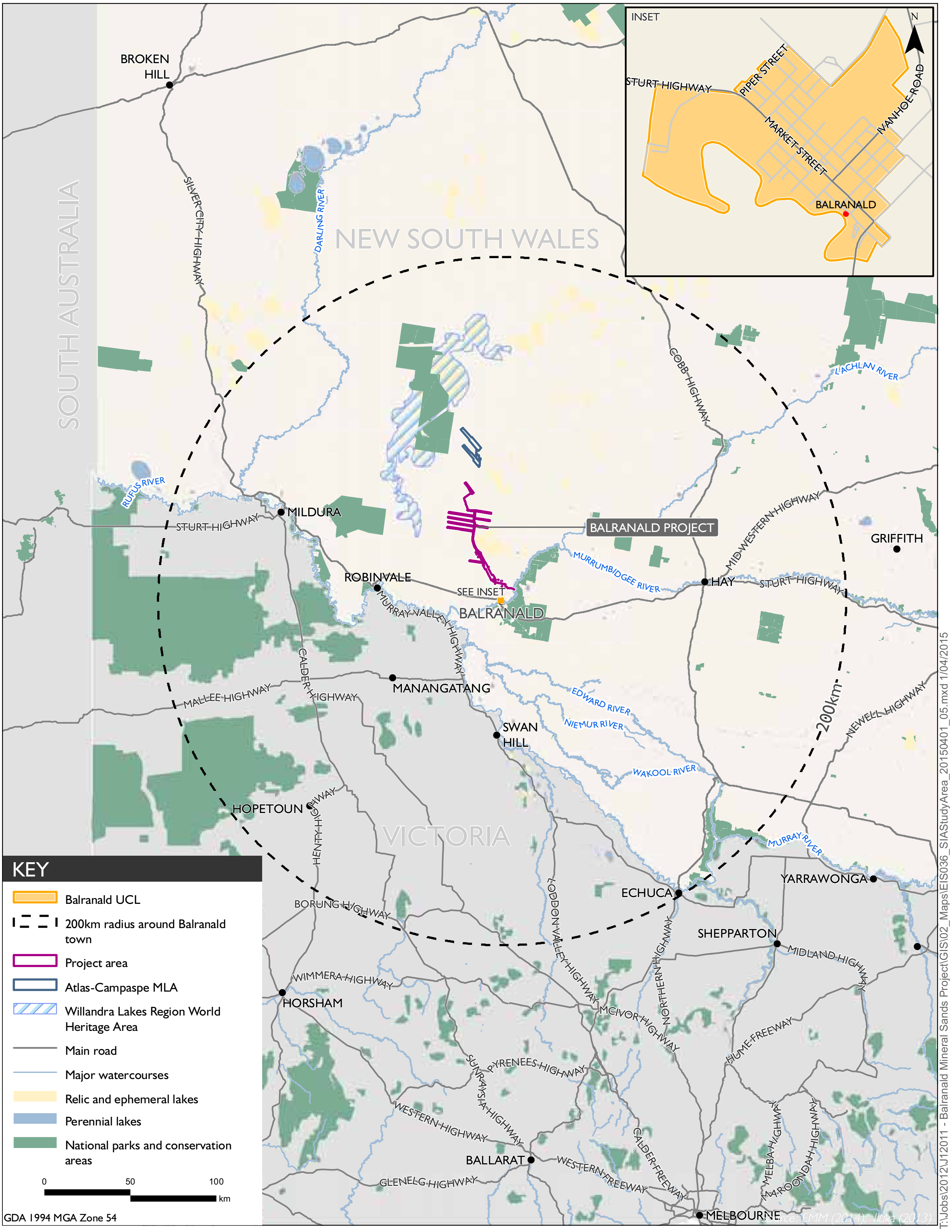
Source: *ABS 2006 and 2012.*

Notes: *1. Changes to ABS collection catchment for Gazetted Localities occurred for 2011 census data.*

2. Department of Planning. 2010. NSW Statistical Local Area Population Projections.

3. The ABS defines the working age (or labour force) as usually resident Australian civilian population aged 15 and over (noting that the retirement age is currently 65).

4. Department of Education, Employment and workplace Relations. Small Area Labour Markets Australia – September Quarter 2014.



Social assessment study area

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 19.1

i Population size, growth and future change

Balranald town and Balranald LGA are characterised by a declining rural population. Balranald town had a population of 1,159 in 2011, which is a decrease of 57 people (or -4.7%) from the population in 2006 (1,216 people). The LGA had a population of 2,283 at the 2011 census. This represented a decline of -6.5% since 2006 census (2,441). This decline is not representative across non-metropolitan NSW, which experienced a population increase of 3.8%, while NSW overall recorded 5.6% population growth during the same period.

Based on the current population trends and NSW Government (DoP 2010) population forecasts, Balranald LGA is likely to experience a continued decline in population through to the year 2036 (-0.7% per year). Non-metropolitan NSW is likely to experience low population growth (1%) over this period.

ii Population structure

In 2011, Balranald town's population had a high representation of people aged between 45 to 54 years (17.4%) and 65 years and over (20.3%) showing an ageing, rural population. Other than the 60 to 84 year and above 85 years cohorts, the smallest cohorts in the town were represented by 25 to 29 year olds and 30 to 34 year olds (3.8 and 3.4% each).

In 2011, the Balranald LGA population was characterised by a 'middle-aged' family structure. Compared to non-metropolitan NSW, the LGA has a higher representation of people aged 45 to 54 years (15.9% to 14.1%) and 35 to 44 years (13.3% to 12.6%), with a higher proportion of children aged 0 to 4 years (7.3% to 6.3%) and 5 to 11 years (9.7% to 9.0%). There is also a high proportion of people aged 65 years and over (15.6%). However, this is lower than non-metropolitan NSW (18.0%). The smallest cohorts in the Balranald LGA, were younger (teenagers) and early working age groups – 12 to 17 year olds (7.6%) and 18 to 24 year olds (6.8%).

In 2011, 50.8% and 51.5% of Balranald town and LGA respectively were male. This compares with 49.3% for NSW overall.

In 2011, 8.6% and 6.8% of the population of Balranald town and Balranald LGA, respectively, were Aboriginal or Torres Strait Islanders. This is higher than non-metropolitan NSW and NSW overall where 4.6% and 2.5% of the population, respectively, were Aboriginal or Torres Strait Islanders.

In 2011, Balranald town had a median age of 44 years and, and Balranald LGA and non-metropolitan NSW had a median age of 41 years. This was above the NSW average (38 years).

iii Household structure

In 2011, Balranald town and LGA had a higher percentage of couples with no children (44.3% and 42.2% respectively) than non-metropolitan NSW and NSW overall. Conversely they each also had a lower percentage of couples with children, particularly in Balranald town. Balranald town and LGA had a much lower proportion of lone person households (15.9% and 12.7% respectively) compared to non-metropolitan NSW and NSW (26.9% and 24.2% respectively).

In 2011, Balranald town, Balranald LGA and non-metropolitan NSW generally had the same average household size of 2.3 or 2.4 persons. This was slightly below the NSW average of 2.6 persons.

iv Economic structure

Reflecting the rural character of the area, in 2011 agriculture, forestry and fishing were the largest employing industries within the LGA (31.2%) with the next largest category being health care and social assistance (9.9%). While agriculture dominated those people employed in Balranald town (sheep, beef cattle (9.2%), and grain farming (6.1%) and fruit and tree nut growing (3.1%)), 7.1% worked in local government administration and 5.9% in school education, reflecting the towns role as a service centre. Employment in the health care and social assistance as well as in the retail trade dominated the rest of NSW and NSW overall.

v Workforce and occupation structure

In 2011, the most common occupations in Balranald town included labourers (18.5%), machinery operators and drivers (13.8%), managers (which include farmers) (13.2%), community and personal service workers (13.2%), and technicians and trades workers (12.2%). The most common occupations in Balranald LGA included managers (28.6%), labourers (17.9%), technicians and trades workers (10.1%), community and personal service workers (9.7%), and clerical and administrative workers (9.7%).

vi Unemployment

Estimates of unemployment are provided by the Commonwealth Department of Employment, generally on an quarterly basis, for statistical local areas (SLAs) as well as on a state and metropolitan/non-metropolitan basis. For Balranald, the Balranald SLA is the same as the Balranald LGA.

The most recently available data is for the first three quarters of 2014. The data indicates that the unemployment rate in the Balranald LGA increased by 1.2% in the first three quarters of 2014 from 3.8% in the March quarter to 5.0% in the September quarter. These quarterly rates were lower than those recorded for NSW. NSWs rate of unemployment stayed at 5.7% for all quarters.

vii Relative disadvantage

Socio Economic Indexes for Areas (SEIFA) is a suite of four summary measures that were created from 2011 Census information. The ABS broadly defines relative socio-economic advantage and disadvantage in terms of people's access to material and social resources, and their ability to participate in society.

The data indicated that Balranald LGA was considered to be relatively disadvantaged in both national and state terms in 2011 as determined by the four indexes. The four indexes are:

- relative socio-economic advantage and disadvantage;
- relative socio-economic disadvantage;
- economic resources; and
- education and occupation.

The relative disadvantage was more pronounced in relation to the overall index and the education and occupation index than in relation to the economic resources and the relative socio-economic disadvantage indexes.

19.2.2 Community services and facilities

i Education

a. Pre-school

The Balranald Early Learning Centre, a community based not-for-profit centre, is located in a BSC-owned building on a large site in Harben Street in Balranald town. The centre is licensed for up to 66 children. It is operated by five permanent part time staff and a cleaner. On average over the last few years, the centre has catered for 25 children (30% pre-school and 70% day care). Staff are employed relative to the number of children enrolled.

As the centre is licensed for 66 children, there is capacity available to accommodate further enrolments, but this would require a commensurate increase in staff.

b. Primary schools

St Joseph's Primary School

St Joseph's Primary School is located in Church Street. It had an enrolment from Kindergarten to Year 6 of 49 pupils in 2014 with five teaching staff and five non-teaching staff. The school is part of the Catholic education system run by the Diocese of Wilcannia-Forbes. The school collaborates with the Balranald Central School on specific events, for example, where a minimum number of pupils are needed to attract particular events.

The 2014 enrolment was the lowest for some years; enrolments have been up to 80 pupils historically.

St Joseph's Primary School's Index of Community Socio-Educational Advantage (ICSEA) rating in 2014 was 953. The ICSEA is a scale that enables comparisons to be made across schools in relation to socio-educational advantage. The value for St Joseph's School represents some slight disadvantage relative to the national average.

Balranald Central School (primary component)

The Balranald Central School (primary component), located on a site fronting Wee Street, had 63 pupils in 2014 spread between Kindergarten to Year 6.

Most of these pupils were drawn from Balranald town with a minority drawn from the surrounding areas including Euston to the west, about halfway to Tooleybuc to the south, halfway to Hay to the east and about 40 km to the north of Balranald. According to the school principal, there has been a steady decline in enrolments since 2007.

c. Secondary school

The secondary component of the Balranald Central School is located on the same site with the primary component. The 2014 secondary enrolment in Years 7 to 12 was 77 pupils. In 2014, the school (Kindergarten to Year 12) had a teaching establishment of 15 with a total of 23 staff employed (including several permanent part time).

As with the primary component, there has been a steady decline in enrolments since 2007 and it is anticipated that this decline would continue.

Balranald Central School's ICSEA rating in 2013 was 939 which represents some slight disadvantage relative to the national average.

d. Other secondary education

Secondary school students in Balranald have several other schooling options, namely, access by daily bus services to several secondary schools located some 100 km away in Swan Hill (either Swan Hill College or McKillop College). There is also the option to attend boarding schools in country Victoria, NSW or metropolitan Melbourne.

ii Health

a. Balranald Health Service

Balranald Health Service (BHS) provides acute and allied health services to the Balranald community on behalf of the NSW Department of Health and comes under the jurisdiction of the Far West Local Health District based in Broken Hill. BHS provides services from the facility located at the eastern end of Market Street.

The BHS operates:

- the Balranald District Hospital which has eight acute beds and an emergency department;
- high level residential aged care with 15 beds; and
- allied health services including dental, physiotherapy, occupational therapy, speech therapy, dietetics, mental health, psychology and radiography available on a visiting basis at varying frequencies.

BHS has one full time general practitioner and a visiting dentist. Both operate from consulting rooms adjacent to the hospital. The School Dental Services provides dental services to the schools in Balranald.

Higher order specialist health services such as cardiology or paediatrics are available for patients via ground transfer at either Swan Hill or Mildura hospitals and other specialist services by air ambulance retrieval to large hospitals in Melbourne or Adelaide. A pharmacy is located on Market Street.

According to the Commonwealth Government's My Hospitals website, in 2010/11 (the latest comprehensive data available), Balranald Hospital had a total of 304 overnight admissions, including 245 emergency admissions and 59 other admissions. For the same period, there were 20 same-day emergency admissions.

b. Balranald Aboriginal Health Service

The BAHS is a new, purpose-designed medical facility located on the corner of Mayall and Court Streets, completed in early 2011. The BAHS has three full time employees. General practitioner services are conducted on a weekly basis by doctors from Mildura. A nurse provides health checks and services on a weekly basis.

Allied health services are provided at the BAHS premises on a regular visiting basis. These services include dietician, podiatry, speech therapist, nutritionist and drug and alcohol outreach. The BAHS is gradually building up the range of services available to the Aboriginal community in Balranald particularly in relation to mental health services and maternal health. The BAHS works in a complementary manner to the BHS.

c. Community support

Community support is provided through a range of services offered by BSC. These include:

- local home and community care;
- Meals on Wheels;
- Bidgee Haven Aged Care Facility (operation);
- Mandola Place units (for people with disabilities); and
- an emergency accommodation unit.

Mallee Family Care (MFC) offers family services such as counselling, play groups, and foster care to both the Aboriginal and non-Indigenous communities as well as providing other agency services such as Centrelink 20 hours a week from its office.

St Vincent de Paul runs a 'Vinnies' retail outlet in Market Street for fund raising as well as providing charitable and emergency services (such as food assistance and emergency accommodation) for local residents and travellers, all on a voluntary basis. Trained volunteers provide counselling, advice and referrals to other agencies such as MFC in Balranald or Family and Community Services (FACS) in either Dareton or Broken Hill.

iii Retail and commercial services

Most local retail and commercial services in Balranald town are located on Market Street or nearby intersecting streets. Shops include two licensed supermarkets, a butcher, bakery, newsagency, hardware (including electrical and furniture), pharmacy and several clothing and gift shops. Professional and other services include a solicitor, accountant, post office, employment agencies, stock and station agent, real estate agent and IT services.

iv Recreational facilities

The majority of the sporting facilities in Balranald town are within the BSC managed Greenham Park. Facilities located in the park include:

- swimming pool complex which includes a 33 m outdoor pool, a medium pool (less than 33 m), and a hydrotherapy pool;
- sporting ovals (football and cricket) and multi-purpose clubroom/facility;
- tennis and netball courts with club facilities;
- nine hole golf course;
- race course and stables (including a pony club) - two horse race meetings are held each year; and
- BMX circuit.

Sporting clubs and the local schools use these facilities on a regular basis.

v Cultural facilities

Cultural facilities in Balranald town include:

- Theatre Royal, Market Street – multi-purpose hall facility which is a venue for community functions and is available for hire;
- The Gallery, located in the historic Masonic Lodge building at 51 Mayall Street which is owned and operated by Balranald Arts & Craft Inc. It is the venue for a range of arts and crafts activities as well as for temporary exhibitions; and
- Balranald Ex-Servicemens Club, Market Street – which hosts regular visiting performers.

In addition, BSC provides the following indoor facilities that are available for hire for community activities:

- Greenham Park Multi-purpose facility;
- Greenham Park Pavilion; and
- Senior Citizens Centre in Market Street.

vi Religion

Balranald LGA is served by three religious denominations – Anglican, Catholic and Presbyterian – the latter two served by full time clergy. All have churches in Balranald town.

All three congregations are long established, but the congregations are small and ageing.

vii Children and youth services

a. Children

Child and maternal health services are provided on a visiting basis at the BHS along with various playgrounds throughout the town.

b. Youth

One of the community challenges and issues identified are limited youth services and programs. These issues were confirmed in discussion with officers from BSC who identified the need for an indoor fitness centre/gym facility as a priority to respond to youth-related needs in particular, as well as a skate park or casual drop-in centre.

viii Emergency services

a. Police

NSW Police have a police station located on Market Street, which is staffed by five general duties officers and two highway patrol officers. The station is staffed every day between the hours of 8.00 am to midnight from Sunday to Thursday and on Friday and Saturday from 8.00 am to 3.30 am. The area policed from the station extends approximately 35 km towards Euston to the west, 40 km towards Kyalite to the south, 80 km towards Hay to the east and 45 km north.

The major policing issues in and around Balranald town are considered to be offences related to intoxication, domestic violence, malicious damage and traffic matters. However, crime is not considered by the police officers consulted to be a serious issue in the local community and the town is considered to be relatively safe. Data from the NSW Bureau of Crime Statistics and Research confirms that crime rates are relatively low compared to non-metropolitan NSW where the predominant major offences in Balranald LGA in 2011, 2012 and 2013 were in the categories of assault and property-related theft and damage. There was only one recorded robbery with a weapon in 2013.

b. Ambulance

The Ambulance Service of NSW maintains an ambulance station in Balranald town with 24 hour operation. The three-vehicle ambulance station is located in Court Street adjacent to the hospital. Four officers attend the station from 8.00 am to 4.00 pm daily and two officers are on-call between 4.00 pm and 8.00 am daily.

The area served by the Balranald station extends generally 80 km towards Hay to the east, 35 km towards Euston to the west, to the Victorian border (75 km) to the south and up to 155 km north.

The pattern of call outs varies from periods when there are no calls over a couple of days to very busy periods. In quiet periods, the staff undertake community relations activities with schools and other groups. Staff work closely with the hospital and other health services in Balranald and assist Ambulance Victoria with call outs along the Murray River.

According to the Ambulance officers consulted, the current staff and resources could handle more call outs but if there were to be a large increase in demands, additional staff and/or resources would be required.

c. Fire

Balranald town is served by the NSW Fire Brigade with a station located at 123 Market Street with four employees. The NSW Rural Fire Service has a station located in Market Street adjacent to the Voluntary Rescue Association (VRA). It forms part of the Lower Western Region South region. According to personnel consulted, the NSW Rural Fire Service could handle more call outs but if there were to be a large increase in demands, additional staff and/or resources would be requested.

d. Voluntary Rescue Association

The VRA is the primary rescue service for the Balranald LGA and those parts of surrounding LGAs that are closer to Balranald town than other towns – an area of 38,000 km^2.

The VRA has 15 volunteers and is largely self-funded with some support from BSC and the NSW Volunteer Rescue Association. Its base in Market Street, Balranald is equipped with:

- primary rescue truck;
- back up truck;
- troop carrier for personnel transport; and
- spare truck.

The Balranald VRA records an average of 18 call outs annually – mainly motor vehicle crashes on the Sturt Highway, as well as river rescues, farm and industrial accidents, and motor vehicle crashes on minor roads.

ix Public and community transport services

Intra and interstate public bus services serve Balranald town on a regular basis. CountryLink operates a daily service between Cootamundra and Mildura which stops in Balranald town daily.

Long distance bus services between Adelaide and Sydney are provided on weekdays by Greyhound Australia with east and westbound services to Adelaide stopping in Balranald town once daily.

Balranald Community Transport Services (operated by the Far West Health Service) operates two return bus services; on the first Friday of each month from Balranald town to Swan Hill and on alternate Wednesdays from Balranald town to Mildura.

There are no scheduled air services to or from Balranald Airport located to the north of the town.

19.2.3 Housing and accommodation

Housing in Balranald town is characterised by a high proportion of detached dwellings. In 2011, of the total stock (1,094 dwellings), approximately two thirds were owner-occupied while one third were part of the rental market. 2011 Census data indicated that 15.5% of private dwellings were unoccupied – a higher proportion than for the rest of NSW.

There are minimal issues for vendors wanting to sell for prices under $100,000 while it is harder to sell existing houses over $130,000 to $140,000. At this higher price range, the alternative of buying a residential lot for under $50,000 and building a project house becomes more attractive.

There is a reasonable supply of vacant residential lots, including half acre lots.

The current (January 2015) average house price in the Balranald LGA is $137,500.

Given Balranald town's location on the Sturt Highway, the town is generally well serviced by tourist and temporary accommodation in the form of motels and a caravan park. There are six motels providing up to 95 rooms. The caravan park provides 17 cabins as well as 33 powered and 33 unpowered sites.

For short periods during the year, depending variously on school holidays, local events such as race meetings, fishing competitions, the Balranald 5 Rivers Outback Festival and business demands, all this tourist accommodation may be taken up. At other times there is usually some availability of tourist and temporary accommodation.

19.3 Impact assessment

19.3.1 Stakeholder engagement

Community consultation is an important part of the Balranald Project as it allows stakeholder values, issues, impacts and opportunities to be identified and included in the Balranald Project's design and implementation. A second important function is to properly inform interested parties about the Balranald Project, its potential impacts, and how they would be managed and mitigated.

Details on stakeholder engagement undertaken for the Balranald Project are provided in Chapter 7. A full list of stakeholders consulted as part of the social assessment is provided in Appendix O.

19.3.2 Method

Social impacts of the Balranald project have been considered in terms of the following aspects:

- duration – related generally to the length of, for example, the construction and operations phases;
- significance – whether the impact is considered to be of 'high', 'medium' or low' significance;
- extent – the area, people, facilities and/or services potentially affected;
- potential to mitigate the impact – availability of measures which can reduce or mitigate negative impacts; and
- other considerations – whether the impact is direct or indirect, positive or negative, or cumulative with impacts from other projects in the Balranald LGA.

The potential impacts of the Balranald Project are discussed in the following sections. These are discussed in phases, including:

- planning feasibility and approvals phase;
- construction and operational phases; and
- rehabilitation and decommissioning.

19.3.3 Planning feasibility and approvals phase

Exploration and other investigations related to the Balranald Project have been undertaken by Iluka since at least the mid 1990s. There has been a heightened level of activity in and around Balranald town associated with the investigations supporting the preparation of feasibility studies, engineering studies and the EIS. The awareness of the Balranald Project by the local and regional community is very high. Based on engagement with stakeholders, there is generally a positive and supportive attitude towards the Balranald Project from the local and regional community.

i Affected property owners

A small number of property owners, whose land would be directly and indirectly affected by the Balranald Project during the planning, feasibility and approvals phase, have mixed attitudes towards the project.

Many of the properties that may be affected by mining is currently used for agricultural activities. The area that the Balranald Project would directly impact is sparsely populated.

Where directly impacted land is remote or isolated from the majority of a property's productive area, the relevant property owners have stated that they are not too concerned about the direct impact of the Balranald Project, provided that appropriate commercial and functional arrangements have been negotiated and mitigation measures are put in place to appropriately manage environmental impacts (eg air quality). Most of these property owners have stated that they are seeking a definitive decision about whether and when the Balranald Project would proceed, but are not otherwise unduly concerned on a day-to-day basis about the prospect of the project. However, while generally supportive of the Balranald Project, there appears to be some tendency for property owners to defer investment in the development or maintenance of farm infrastructure which may be subsumed by mining activities until there is a definite commitment to the Balranald Project.

For some other property owners, there is a level of concern regarding a range of potential functional impacts (either directly or indirectly) of the Balranald Project on agricultural activities and productivity, principally related to truck movements, dust generation, noise and the ability to arrive at appropriate compensation agreements with Iluka given individual landholders' circumstances. In this latter group, some property owners are experiencing a degree of concern and anxiety on a day-to-day basis because a decision about the timing of the Balranald Project and related negotiations has greater implications for the next stages of their lives.

Most property owners who would only be affected by the development of lineal infrastructure such as the water supply pipeline are relatively unconcerned at this stage provided appropriate compensation and functional arrangements (ie land access) are negotiated with Iluka.

For directly affected property owners, potential impacts on agricultural activities are generally of high significance, but the ability to resolve these impacts is also high through negotiation of appropriate compensation agreements with Iluka, as well as regular communication on the development of the project and key milestones that impact land access negotiations. Significant progress on land access negotiations has been achieved for many of the relevant properties with further access requirements being identified and confirmed. It is forecasted that the land access negotiations will be finalised in 2015 in readiness for future project development.

ii Community concerns

Based on stakeholder engagement with the broader local and regional community, there is generally a positive attitude towards the Balranald Project. This is particularly emphasised in relation to employment and economic benefits that are perceived to be associated with the Balranald Project.

The main interest in the Balranald Project at the planning, feasibility and approvals phase appears to be from residents who have family members who might seek employment at the mine or from business people who hope to benefit from increased economic activity.

The community are relatively optimistic about the Balranald project but are realistic about the potential population increase, corporate decision making and regulatory approvals required. It is likely that once the Balranald Project completes the regulatory approval process and internal corporate approvals in relation its commencement, prevailing uncertainties about the Balranald Project proceeding would probably be replaced with a sense of certainty, optimism and energy.

It is likely that once detailed construction planning commences there would be a demand for increased temporary accommodation and increased trade for some businesses such as the motels and takeaway food shops. BSC may also be involved in related planning activities to assist the smooth commencement of the construction phase. In conjunction with local providers, Iluka may commence some training programs to assist the availability of local workers.

Given the generally supportive attitude of the local community, the scale of any concern about the Balranald Project is considered to be low (ie low significance).

19.3.4 Construction and operational phases

Apart from the differing duration of these two phases, the likely social impacts would be similar as they are largely related to the workforce and related increased demands on certain community, retail and hospitality services and facilities in Balranald town, as well increased demand for housing and temporary accommodation.

i Workforce

Peak workforce details indicate that:

- the Balranald Project would employ a peak construction and operational workforce of 225 and 550 workers, respectively;
- during the overlap of the construction and operational phases, the peak workforce total about 450 works;
- given leave, including leave between shift rosters, there would be a peak of 158 construction workers and 385 operational workers on-shift at any one point in time;
- during the overlap of the construction and operational phases, there would be a peak of 315 workers on-shift at any one point in time; and
- due to Iluka's work, health and safety policies, it is expected the vast majority of the construction and operational workforce (95%) would stay at the accommodation facility while on-shift, with a minority (5%) commuting to the project area.

It is likely that, given the size and skill set, the majority of both the construction and operational workforces would be sourced from the Balranald regional area (within 200 km) with a proportion drawn from further away. Such an approach is consistent with the labour management on other mineral sands mines in regional areas of Australia.

It has been assumed that a small portion (5%) of the operational workforce would relocate with their families to Balranald LGA. Based on the peak workforce numbers, 28 workers are anticipated to relocate. Based on the NSW average household size of 2.6 persons, this would lead to a population increase of 73 people within the Balranald LGA.

In addition, the Balranald Project would generate indirect or flow-on jobs within the region during both the construction and operational phases. This is anticipated to be approximately 36 indirect jobs generated during the operational phase of the Balranald Project. Should 50% of the indirect jobs generated by the Balranald Project be taken up by the unemployed (52 people in the Balranald LGA as of September 2014) the population increase in the Balranald LGA generated by indirect jobs would be 47 people.

With a population increase of 73 people associated with the relocation of the operational workforce and 47 people associated with the generation of indirect jobs, the Balranald Project could increase the population of the LGA by about 120 people. Given the Balranald LGA is anticipated to experience a continued decline in both its population growth rate and its total population through to 2036 based on a reduction in the birth rate and net migration any population increase associated with the Balranald Project would help offset past and forecast population decline.

Based on experience on other projects in the Murray Basin, there would be opportunities through Iluka's proposed development of a local employment and business policy for local people and businesses to seek employment on or provide additional services to the Balranald Project (refer mitigation measures in Section 19.4. This may put pressure on the available labour pool for existing employers within the town. The prospect of enhanced employment availability in and around Balranald may also attract people from elsewhere to come to the district on the prospect of gaining employment. This may also put additional pressure on the local community services.

The Balranald Project would also generate a large non-local workforce. The size and presence of a large non-local workforce would have several potential impacts for Balranald town, namely:

- an increase in the use of local community, retail and hospitality services and facilities – which may result in some positive and some negative impacts depending on demands generated by the incoming workforce; and
- an increase in the presence of 'non locals' around town with potential for both positive and negative impacts on social amenity.

This impact is considered to be of 'high' positive significance because of the extent of work opportunities generated by the Balranald Project, particularly for the unemployed in the Balranald LGA, and the potential for offsetting of population decline.

ii Increased demand for accommodation

During the construction and operational phases of the Balranald Project, as well as the overlap of both phases, the majority of the workforce would reside in the accommodation facility.

Given the scale and length of the initial construction period of the Balranald Project, it is likely that there would be some indirect impacts on the wider accommodation market in Balranald. There is capacity in the temporary and tourist accommodation sector in Balranald town. However, given the small supply it is possible this would fill up with project related visitors who may not be able to be accommodated in the accommodation facility from time to time. Several operators have indicated to Iluka opportunities to increase accommodation services should a demand be identified.

The population increase generated by the Balranald Project would generate demand for about 46 dwellings in the Balranald LGA. Given the limited existing availability, this increased demand may put some short term stress on the availability and price for the wider community.

Given Iluka's commitment to develop an accommodation facility that would cater for virtually all of the direct workforce during the construction and operations periods, any impacts on wider accommodation resources in Balranald is considered to be of 'low' significance.

iii Demands on community and retail services

There are unlikely to be any substantive demands during either the construction or operational phase on existing community facilities and services that cater principally for children and families because it is anticipated that there would only be a relatively small in-migration of new families to the Balranald LGA directly as a result of the Balranald Project.

Generally, any increased demands on or use of community services and facilities in Balranald as a result of the Balranald Project would only slightly reduce the likelihood of further reductions in these services given the projected population decline for Balranald.

However, there is likely to be some increased demand in the following sectors of Balranald's community infrastructure from the Balranald Project workforce that would reside in the accommodation facility:

- use of local retail and hospitality facilities;
- emergency visits to the local doctor, dentist and hospital resulting from 'normal' health issues or small scale accidents;
- use of local recreation facilities particularly those related to outdoor activities such as swimming, golf and fishing; and
- demand for an indoor fitness centre/gym.

Generally the significance of additional demands on retail, hospitality and community services are considered to be 'low' because of the existing capacity in most community services sectors in Balranald. The lead-up time to project commencement would assist local stakeholders to develop a comprehensive understanding of the size, sourcing and accommodation arrangements for both the construction and operations workforce.

iv Impacts on social amenity

Community image and social cohesion issues related to 'fly-in fly-out communities' (and, by implication, to drive-in drive out communities) in Australia's resource sector were addressed in a recently released report undertaken by the House of Representatives Standing Committee on Regional Australia (2013).

Key issues in relation to community image and social cohesion identified in the Standing Committee's report that have some relevance to the Balranald Project are the potential for:

- the development of an 'us and them' division-between the established Balranald community and the Balranald Project workforce;
- a real or perceived reduction in community safety in and around Balranald town; and
- a lack of respect from the incoming workforce for local community values and the community capital through voluntary effort that has developed many of the local community's facilities.

During both the construction and operational phases of the Balranald Project, there would be the presence of more people and traffic movements in and around the shops and other businesses in the town centre. However, the increased level of activity around Balranald town that would be generated by the Balranald Project workforce is considered to be positive because of the likely economic benefits that would be experienced in the town.

The significance of impacts on the social fabric of Balranald town is considered to be of 'medium' significance because of the peak size of the Balranald Project workforce (up to 550 workers during the operational phase) relative to the permanent population of Balranald town (approximately 1,159 people in 2011).

v Construction and operational traffic impacts

As there are no rail transport connections to the Balranald Project, road transport would be utilised during both the construction and operational phases. There is the potential that vehicle movements generated by the Balranald Project would impact on resident's amenity, such as potential noise impacts.

Traffic impacts have been discussed in Chapter 18 and noise impacts from traffic have been discussed in Chapter 9. These indicate that:

- due to existing low traffic volumes, there would not be any significant traffic impacts in terms of level of service or traffic flow impacts for any road in either Balranald town or Tooleybuc; and

- predicted road traffic levels would satisfy relevant road traffic noise criteria on all transport routes, for construction traffic and product haulage.

The significance of traffic impacts during the construction and operational phases is considered to be of 'low' significance because of the results of the transport and noise assessments.

vi Cumulative impacts with other mining projects

There is the potential for some cumulative social impacts associated with the Atlas-Campaspe Mineral Sands Project. Resource Strategies (2013) estimates that the Atlas-Campaspe Mineral Sands Project could lead to a population increase of 36 people in the Balranald LGA. With the Balranald Project adding to a population increase of approximately 120 people, cumulatively, the two projects could increase the population of the Balranald LGA by 156 people and generate demand for 60 dwellings.

Similarly with workforce and accommodation impacts of the Balranald Project alone, cumulatively the two projects would:

- help to offset population decline in the Balranald LGA and region;

- increase the overall occupancy rates for tourist and temporary accommodation, which could result in short term stresses during community events; and

- place some short term stress on the availability and price of accommodation for the wider community (both in the property market and rental properties).

Cumulative impacts are considered to be of low significance. While there may be some short terms stress on the provision of accommodation, cumulatively the projects would provide greater work opportunities and provide more potential for offsetting of population decline.

19.3.5 Rehabilitation and decommissioning

At the completion of the mining activities, infrastructure would be decommissioned and disturbed areas progressively rehabilitated over several years until they are formally closed.

As result of the completion of the mining activities, most of the Balranald Project's operational jobs would cease for both the non-local and local workforce components. As the Balranald Project workforce winds down, there would be reductions in the use of community services and facilities and the retail and hospitality sector in Balranald. In relation to the retail and hospitality sectors in particular, there may be some job reductions if there are any substantial reductions in levels of business.

However, the history of the mineral sands industry in the Murray Basin indicates that as one mining project is completed, another project generally comes on stream. This is particularly the case with Iluka as they aim to maintain availability of product (HMC) to supply its processing and distribution facilities in Victoria. As a result, a proportion of operational workers usually transfer to the next project in the region.

The decommissioning of the Balranald Project has the potential to result in the permanent loss of the operations jobs for the regional/commuting and locally based workforce together with related flow-on economic benefits within the Balranald community. Assuming that another mineral sand project is not developed in the Murray Basin at the time of decommissioning of the Balranald Project, the significance of this impact is considered to be 'medium. However, assuming another mineral sands project is developed in the Murray Basin as the Balranald Project winds down, which is likely to be the case, the significance of this impact is considered to be 'low'.

19.3.6 Results

The results of the social assessment against the phases of the Balranald Project are provided in Table 19.2.

Table 19.2 Summary of potential social impacts during phases of Balranald Project

Potential social impacts by project phase	Duration	Significance	Extent	Potential to mitigate
Planning, feasibility and approvals				
Potential impacts on directly affected property owners	Until negotiations with Iluka completed	High	Directly affected property owners	Yes
Community concerns about the Balranald Project	Until project determination	Low	Balranald town and regional community	Yes
Construction and operations				
Workforce issues related to the limited number and availability of suitably skilled local workforce, requiring much of both workforces to be drawn from the wider regional area	Construction and operational phases (about 10 years)	High (positive)	Balranald LGA and regional area within 200 km	Yes
Increased demand for accommodation and housing (in addition to proposed accommodation village)	As above	Low	Balranald LGA	Yes
Increased demand for retail, hospitality and community facilities or services	As above	Low	Balranald town	Yes

Table 19.2 Summary of potential social impacts during phases of Balranald Project

Potential social impacts by project phase	Duration	Significance	Extent	Potential to mitigate
Changes in social amenity	As above	Medium	Project area and Balranald town	Yes
Construction and operational traffic impacts	As above	Low	Public roads	Yes
Cumulative impacts of the Balranald Project with other mineral sands projects in the LGA (ie Atlas-Campaspe Mineral Sands Project)	As above	Low	Balranald LGA	Yes
Rehabilitation and decommissioning				
Loss of most Balranald Project jobs	Immediate post completion of mining operations	Low[1]	Balranald LGA and regional area within 200 km	Yes
Related impacts on community services and organisations	As above	Low[1]	Balranald town	Yes

Notes: 1. Assumes that another Iluka project would replace the Balranald Project in the Murray Basin.

19.4 Management and mitigation measures

This section describes the mitigation measures Iluka proposes to implement to address the potential social impacts outlined previously.

Iluka is committed to entering into an agreement with BSC in relation to Iluka's contributions to the local area and has commenced discussions regarding the scope and terms of the agreement.

19.4.1 Workforce issues

A key matter to be addressed in relation to the Balranald Project's workforce is to ensure opportunities are created for local residents to gain employment on the Balranald Project and resource any local business workforce shortages created by the Balranald Project.

Iluka's approach to employment embodies the following principles:

- a preference for local employment wherever possible - this approach has been employed across the Murray Basin operations, with a large proportion of the workforce drawn from the relevant local region;
- local contractors are encouraged to tender for work, both during the construction and operations phases; and
- use of local businesses such as hotels, motels and restaurants.

In order to achieve this outcome, Iluka proposes to:

- provide advance information about its approach to workforce sourcing, recruitment policies of local people, and work arrangements in relation to matters such as shifts, transport and work, health and safety obligations;

- work with recruitment, education and training providers in Balranald, Swan Hill and Mildura to encourage the provision (in advance of project commencement) of future employment and training opportunities for skills that would be directly and indirectly generated by mining projects;

- continue liaison with relevant agencies to ensure that any wider community issues about training and labour availability for 'vacated' local jobs in favour of jobs on the Balranald Project does not become an 'Iluka' issue;

- participate, as appropriate, in business groups, events or programs as part of a Balranald Business Association and/or provide training programs directly relevant to project needs or broader industry skills; and

- participate in the local mining liaison committee that has been established by BSC so that relevant project information can be provided and community feedback received.

The provision of these activities would be supported by Iluka's proposed development of a local employment and business policy. The intent of this policy is to provide relevant commitments to drive Iluka activity in potential areas including:

- product and service procurement;

- equitable or contracted procurement;

- pre-qualification assistance;

- employment advertising and resourcing;

- training assistance or participation, and

- service referrals.

19.4.2 Housing and accommodation

i Workforce accommodation

To address workforce housing and accommodation requirements, Iluka proposes to develop an accommodation facility for the life of the Balranald Project (including construction, operations and rehabilitation phases).

ii Flow-on accommodation demands

Due to the relatively small volume of potential new residents to Balranald LGA as a result of the Balranald Project, it is not anticipated that this would impact the availability of accommodation for existing or other new residents. Relatively low house prices, along with affordable land and new build developments, would provide an even opportunity for non-project related home purchasing or leasing. In terms of short-term accommodation demand (ie hotels and motels during early construction works), Iluka may restrict availability of supply to other users during peak demand periods. Iluka will investigate opportunities where it may reduce its local short-term accommodation demand, at defined periods, such as during large community events. Iluka will work with local short-term accommodation providers, event planners and BSC's tourism development officer to identify such periods and determine what, if an, modifications can be made to Iluka scheduling and accommodation demand.

iii Rental and housing and land development markets

The Balranald Project may place some short term stress on housing availability and the capacity of some community services in Balranald town. It is likely that the private sector would respond to this demand.

However, to assist the identification and management of any housing availability, Iluka proposes to:

- maintain dialogue with stakeholders who regularly monitor the local housing market relative to any direct Iluka requirements;
- continue engagement with BSC, other mining companies in the LGA and accommodation suppliers, to monitor general short-term accommodation usage by Iluka and any impacts on other accommodation sectors;
- consult with Cristal to ensure that potential negative social impacts result from any concurrent stages of project construction and operation are minimised; and
- augment the accommodation facility with additional temporary accommodation if required.

19.4.3 Community services

Where there may be some project-related demands on certain community services, Iluka proposes to:

- have discussions with health and emergency services (ambulance, fire and rescue services) prior to commencement of construction, to ensure that there would be appropriate interface arrangements for operational matters;
- provide advance briefings about corporate purchasing policies and assistance to local businesses to become pre-qualified to assist them to tender for the supply and/or delivery of goods and services to Iluka during the construction, operational and rehabilitation/decommissioning periods; and
- provide a conduit between local businesses and major Iluka contractors.

19.4.4 Social amenity

To maintain and further develop positive relations between Iluka and the Balranald community, Iluka proposes to:

- build on the existing base of community goodwill in the Balranald community by ensuring, through the nominated mitigation and management measures presented in this social assessment as well as a regular stakeholder communications program, to ensure that the benefits to the community as a result of the Balranald Project are realised; and
- to emphasise acceptable behaviours in the Balranald community as part of its induction program for the incoming workforce.

19.4.5 Rehabilitation and decommissioning

At the completion of the mining activities, the Balranald Project's mine infrastructure would be decommissioned and the mine sites progressively rehabilitated over several years. While it is likely there would be some permanent loss of jobs, the timing of operational wind down and ultimate site decommissioning would be known and communicated in advance. Iluka would work with relevant stakeholders to provide information about the timing of these final stages and appropriate support to employees, suppliers and the community as may be required.

There is likely to be the opportunity for a proportion of the Balranald Project workforce to transfer to a subsequent mineral sands project in the region should opportunities eventuate into the future.

19.5 Conclusion

Based on the results of the social assessment, the net community benefit of the Balranald Project for the Balranald community is considered to be positive. This assessment is based on the outcomes of comprehensive stakeholder engagement with the Balranald community and the test of whether a proposal is likely to have, in planning terms, 'acceptable' or 'reasonably acceptable' outcomes.

The key social benefits of the Balranald Project as a result of employment and expenditure are considered to be:

- enhancement of the local and regional economies; and
- assisting to arrest predicted local and regional population decline, diminishing availability of services and facilities in the Balranald region and declining community sustainability.

The Balranald Project has the potential to diversify and strengthen the region's economic base. It would likely increase the size of a number of industry sectors — particularly mining, but also mining related services such as mechanical repairs, utilities, wholesale and retail trade, accommodation and entertainment.

Businesses in the region would likely benefit through direct expenditure and the extra money injected into the area through mine employment and services catering to the Balranald Project.

These factors mean the economy of the Balranald region could be more resilient in the short and longer term. During construction and operations there would be greater economic activity and employment opportunities than currently exist. The social benefits of stronger local and regional economies would include more diverse employment opportunities for local residents and the availability of enhanced retail and other businesses.

Although the Balranald Project has the potential to have some negative social, through the application of identified mitigation measures, the identified impacts could be avoided, reduced to acceptable levels or managed through the life of the Balranald Project. As a result of the key social benefits of the Balranald Project identified above, it is expected that the project would have a net community benefit for the Balranald community.

20 Economics

20.1 Introduction

The SEARs identified specific requirements to assess economic impacts of the Balranald Project, including:

> an assessment of the likely economic impacts of the development, paying particular attention to:
>
> - the significance of the resource;
> - economic benefits of the project for the State and region; and
> - the demand for the provision of local infrastructure and services.

To address these requirements, an economic assessment of the Balranald Project was prepared by Gillespie Economics (Appendix P). Commercially sensitive information contained in the economic assessment has been blacked out. A copy of the assessment without the information blacked out has been separately provided to DP&E for the purpose of its assessment of the Balranald Project.

The economic assessments were completed in accordance with the following guidance documents:

- *Draft Guideline for Economic Effects and Evaluation in Environmental Impact Assessment* (the draft 2002 guideline) (James and Gillespie 2002);
- *Guideline for the use of Cost Benefit Analysis in mining and coal seam gas proposals* (the 2012 guideline) (NSW Government 2012); and
- *NSW Government Guidelines for Economic Appraisal* (NSW Treasury 2007).

This chapter provides a summary of the economic assessment prepared by Gillespie Economics.

20.2 Existing environment

The assessment of the potential economic impacts of the project on agricultural resources provides information of the value of the agricultural and mining industries to the NSW and local/regional economies. For the purposes of the assessment, Gillespie Economics has defined the region as comprising the LGAs in an approximate 200 km radius of the Balranald Project, including the LGAs of Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth, Mildura and Swan Hill.

20.2.1 New South Wales

i Land use

Agricultural lands cover approximately 81% of NSW (Australian Natural Resources Atlas [ANRA] 2009a). While the total agricultural land area in NSW has declined marginally since 1960, the area of land under major food crop production (wheat and barley) has increased.

Mining land use is a small fraction of the area of NSW with less than 0.1% of the total NSW land area taken up by mining (Bureau of Regional Science 2009).

In NSW, dryland and irrigated cropping land covers an area of 84,878 km^2. Mining covers an area of 630 km^2, 0.74% of the area of cropping lands (Table 20.1).

Table 20.1 NSW land use

Land use	Area (km^2)	Area (%)
Nature conservation	61,058	7.6%
Other protected areas	2,478	0.3%
Minimal use	59,178	7.4%
Grazing native vegetation	309,428	38.6%
Production forestry	25,242	3.2%
Plantation forestry	4,200	0.5%
Grazing modified pastures	222,164	27.7%
Dryland cropping	74,692	9.3%
Dryland horticulture	390	0.0%
Irrigated pastures	3,160	0.4%
Irrigated cropping	10,186	1.3%
Irrigated horticulture	1,073	0.1%
Land in transition	951	0.1%
Intensive animal and plant production	243	0.0%
Intensive uses (mainly urban)	10,218	1.3%
Rural residential	4,387	0.5%
Mining and waste	630	0.1%
Water	11,352	1.4%
Total	**801,030**	**100.0%**

Source: Bureau of Rural Sciences (2009).

ii Employment

The NSW agricultural industry directly provides employment for 68,883 people or 2.3% of total employment in NSW (ABS, 2011a). Payment to agriculture, forestry and fishing employees in 2010-11 was $1,539 M and value-added was $7,062 M. Gross operating surplus and gross mixed income from agriculture, forestry and fishing was $6,908 M (ABS 2011b).

Mining directly employs 29,798 or 1.0% of total employment in NSW (ABS 2011a). Payment to mining employees in 2010-11 was $2,466 M and value-added was $10,633 M. Gross operating surplus and gross mixed income from mining was $10,035 M (ABS 2011b).

Mining is a more significant sector than agriculture in terms of payments to employees, value-added and gross operating surplus and gross mixed income. However, agriculture employs more people, albeit while using a much larger area of NSW to achieve this employment.

iii Economic growth

Agriculture has historically supported the economies of regional areas. However, these regional economies are facing a number of trends including:

- loss of significant industries such as abattoirs and timber mills from many rural areas;

- increased mechanisation of agriculture and aggregation of properties, resulting in loss of employment opportunities in this industry;
- preference of Australians for coastal living, particularly for retirement; and
- preference of many of today's fastest growing industries for locating in large cities (Collits 2001).

The result is that there has been declining population growth in 47 out of 96 rural SLAs that are located in non-coastal statistical subdivisions in NSW (excluding Hunter Statistical Division) (ABS 2011c). There has also been a decline in the population of smaller towns even in regions that have been growing.

Trends in agriculture are leading to improved productivity, but reduced economic stimulus in regional areas, as demand for inputs such as labour decline. In general, the prosperity of rural areas that are reliant on agriculture has also been in decline.

It is increased or new spending in regions that contributes to economic stimulus and growth. One potential source of new spending is mining projects that utilise the resource endowments of a region. Studies (Gillespie Economics 2003, 2007) have shown that mining projects provide significant new economic activity to regional and rural economies through direct expenditures on inputs to production as well as the expenditure of employees. This latter stimulus is enhanced by the high wages paid in the mining sector.

Mining projects can also broaden the economic base of regions, thereby insulating the economy from external shocks such as droughts and downturns in agricultural commodity prices (Collits 2001).

iv Water

In NSW, the agriculture sector consumes the largest volume of water with 2,127 GL, or 49% of NSW water consumption in 2009-2010. Mining is a relatively small consumer of water, using 62 GL or 1% of NSW water consumption in 2009-2010 (Table 20.2).

Table 20.2 NSW Water Consumption 2009-2010

Sector	GL	%
Agriculture	2,127	49%
Forestry and fishing	1	0%
Mining	62	1%
Manufacturing	142	3%
Electricity and gas	68	2%
Water supply(a)(b)	1,001	23%
Other industries(c)	357	8%
Household	565	13%
Total	**4,323**	**100%**

Source: *ABS (2011d).*

Notes *(a) Includes sewerage and drainage services.*

(b) Includes water losses.

(c) Includes aquaculture and services to agriculture.

Water productivity is one measure of water efficiency and can be expressed as the amount of output produced from one unit of water. Table 20.3 provides data on water consumption and industry gross value added for 2009–2010, from which water intensity by industry can be calculated. Mining in Australia recorded (on average) $196 M in gross valued added per GL of water consumed in 2009–2010. This compares to the agriculture sector which generated, on average, $3 M in gross value added for every GL of water consumed.

Table 20.3 Industry gross value added for water using industries 2009–2010 (Australia)

Industry		**Industry gross value added[(a)]**	**Water consumption**	**Industry gross value added per GL of water consumed**
		$M	**GL**	**$M/GL**
Agriculture, forestry and fishing	Agriculture	24,265	6,987	3
	Aquaculture, forestry, fishing	4,499	200	22
	Total agriculture, forestry and fishing	28,764	7,187	25
Mining	Coal mining	22,576	76	298
	Oil and gas extraction	26,340	34	785
	Other mining[(b)]	38,880	336	116
	Exploration and mining support services	8,309	44	187
	Total mining	96,105	490	1,386
Manufacturing	Food, beverages and tobacco	23,953	301	80
	Wood and paper products	7,736	81	96
	Printing, publishing and record media	4,088	4	941
	Petroleum, coal, chemical and associated products	17,807	77	230
	Non-metallic, mineral products	5,783	33	176
	Metal products	21,310	139	153
	Machinery and equipment	19,881	9	2,134
	Other manufacturing (includes furniture)	3,047	1	2,998
	Total manufacturing	103,605	645	6808
Electricity and gas		18,837	297	64
Water supply, sewerage and drainage		7,191	1,893	4
All other industries		944,442	1,084	871
Total		**1,198,944**	**11,596**	**9,158**

Source: *ABS (2011d).*

Notes: *(a) At 2009–10 current prices.*

(b) Includes services to mining.

20.2.2 Region

As previously stated, the region is defined as the LGAs of Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth, Mildura and Swan Hill. However, some information is also provided in relation to the Balranald LGA and the LGAs of the total region that are located in NSW.

The total region has a combined land area of about 10 million hectares (Mha), of which 79% is agricultural land (see Table 20.4). Of this agricultural land, 3% is irrigated with annual irrigation volumes of approximately 1,099 GL. The total value of agricultural production in the region in 2006 is estimated at $1,379 M. The value of agriculture in Balranald LGA, in 2006, is estimated at $83 M (see Table 20.4).

Table 20.4 Agricultural land use and value of production in region 2006

	Units	Balranald	Balranald, Deniliquin, Hay, Murray, Wakool, Wentworth	Total region
Area				
Land area	ha '000	2,170	7,130	9,951
Area of agricultural land	ha '000	1,727	6,435	7,862
Irrigation				
Area irrigated	ha '000	8	178	236
Irrigation volume applied	ML	42,863	760,165	1,081,614
Other agricultural uses	ML	1,675	14,943	17,608
Total water use	**ML**	**48,443**	**778,851**	**1,117,271**
Area irrigated as proportion of agricultural land	%	1%	2.8%	3.0%
Value				
Gross value of crops	$M	57	401	1,163
Gross value of livestock slaughtering	$M	17	102	134
Gross value of livestock products	$M	8	61	81
Total gross value of agricultural production	**$M**	**82**	**564**	**1,378**

Source: ABS (2011).

Note: Totals may have minor discrepancies due to rounding.

The input-output table developed for the region (see Appendix P) provides an indication of the direct relative significance of the different agricultural sectors, affirming other agriculture (which includes grapes and fruit growing) and grains as the main agricultural sectors.

Total employment in the agricultural industry in the region in 2011 was 5,353 (ABS, 2013). Table 20.5 provides a more detailed employment by industry breakdown which indicates that the main agricultural employment is in grape growing, other grain growing and grain-sheep or grain beef cattle farming.

Table 20.5 Employment by agricultural sectors in the region 2011

Sector	No.
Agriculture, forestry and fishing	30
Agriculture	190
Nursery production (outdoors)	84
Turf growing	9
Floriculture production (outdoors)	15
Mushroom and vegetable growing	3
Mushroom growing	44
Vegetable growing (under cover)	3
Vegetable growing (outdoors)	213
Fruit and tree nut growing	160
Grape growing	1,355
Berry fruit growing	3
Stone fruit growing	184
Citrus fruit growing	421
Olive growing	12
Other fruit and tree nut growing	181
Sheep, beef cattle and grain farming	8
Sheep farming (specialised)	356
Beef cattle farming (specialised)	133
Beef cattle feedlots (specialised)	5
Sheep-beef cattle farming	106
Grain-sheep or grain-beef cattle farming	675
Rice growing	7
Other grain growing	723
Cotton growing	12
Other crop growing	15
Dairy cattle farming	98
Pig farming	31
Beekeeping	15
Other livestock farming	11
Aquaculture	3
Onshore aquaculture	6
Forestry	8
Logging	8
Fishing, hunting and trapping	4
Hunting and Trapping	8
Forestry support services	8
Agriculture and fishing support services	3
Shearing services	35
Other agriculture and fishing support services	168
Total	**5,353**

Source: ABS (2013b).

Mining and extractive industries in the region directly employees 348 people, with most of these in mineral sand mining (Table 20.6).

Table 20.6 Employment by mining and extractive industries in the region 2011

Sector	No.
Mining	34
Oil and gas extraction	3
Metal ore mining	4
Iron ore mining	7
Mineral sand mining	252
Non-metallic mineral mining and quarrying	3
Gravel and sand quarrying	4
Other construction material mining	15
Other non-metallic mineral mining and quarrying	7
Exploration	3
Mineral exploration	5
Other mining support services	11
Total	**348**

Source: ABS (2013b).

20.3 Impact assessment

20.3.1 Assessment method

Two economic aspects of the Balranald Project have been considered:

- its economic efficiency (ie consideration of costs and benefits), which was evaluated using benefit cost analysis (BCA); and
- its economic impacts (ie the economic activity that the Balranald Project will provide to the local/regional and NSW economy).

The draft 2002 guideline identifies economic efficiency as the key consideration of economic analysis. It identifies BCA as essential for a proper economic evaluation of proposed developments that are likely to have significant environmental impacts. The 2012 guideline endorses BCA as the appropriate methodology for evaluating mining proposals. A consideration of the economic efficiency of the Balranald Project based on a BCA is provided in the following sections.

The 2012 guideline indicates that regional economic impact assessments may provide more information as an adjunct to the economic efficiency analysis. Economic stimulus to the local economy can be estimated using input-output modelling of the regional economy.

It is important not to confuse the results of the economic impact assessment, which focuses on indicators of economic activity (ie direct and indirect output (expenditure/revenue), value-added, income and employment) in a specific region, with the results of BCA which is concerned with the net benefits from a project.

20.3.2 Benefit cost analysis

For a project to be economically desirable, it must be more economically efficient (or beneficial) than a no-project scenario. A project is more economically efficient than having no project if the benefits to society exceed the costs. For mining projects, the main benefit is the producer surplus (net production benefits) generated, while the main costs are any adverse environmental, social and cultural impacts.

Further details on BCA and its application for projects like the Balranald Project are provided in Chapter 3 of the economic assessment (Appendix P).

i Steps in BCA

BCA of the Balranald Project involves the following key steps:

- identification of the base case;
- identification of the Balranald Project and its implications (ie benefit and costs);
- quantification and valuation of the incremental benefits and costs;
- consolidation of value estimates using discounting to account for temporal differences;
- application of decision criteria;
- undertake sensitivity testing; and
- consideration of non-quantified benefits and costs.

The BCA is based on financial, technical and environmental information reported in this EIS.

ii Base case

BCA has to identify a base case or 'no-project' scenario for a comparative measurement of the benefits and costs of the Balranald Project. For the Balranald Project, the base case would continue existing rural and other land uses in the project area.

In contrast, the Balranald Project (as described in Chapter 4) comprises mineral sand mining for a period of about nine years, materials handling and transport of minerals to port for export. At the end of the project it is assumed that the residual value of capital equipment and land would be realised through sale or alternative use.

Alternatives for the Balranald Project have been considered (Chapter 5). However, the Balranald Project assessed in the EIS and evaluated in the BCA is considered by Iluka to be the most feasible alternative for minimising environmental and social impacts whilst maximising resource recovery and operational efficiency. It is therefore this alternative that is proposed by Iluka and was subject to detailed economic analysis.

iii Identification of benefits and costs

Relative to the base case, the Balranald Project may have the potential incremental economic benefits and costs shown in Table 20.7. The main potential economic benefit is the producer surplus (net production benefits) generated by the Balranald Project and any non-market employment benefits it provides, while the main potential economic costs relate to any environmental, social and cultural costs.

Table 20.7 Potential incremental economic benefits and costs of the Balranald Project

Category	Benefits	Costs
Net production benefits and costs	• Value of minerals • Residual value of capital equipment and land at end of project	• Opportunity costs of capital equipment • Opportunity cost of land[1] • Development costs including labour, capital equipment and acquisition costs for impacted properties and offsets[1] • Operating costs of mine including labour and mitigation measures • Rehabilitation and decommissioning costs at end of the project
Potential environmental, social and cultural benefits and costs	• Any non-market benefits of employment	• Greenhouse gas impacts • Noise impacts • Air quality impacts • Surface water impacts • Groundwater impacts • Ecology impacts • Transport impacts • Aboriginal heritage impacts • Non-Aboriginal heritage impacts • Visual impacts

Notes: 1 = the value of foregone agricultural production is included in the value of land.

It should be noted that the potential environmental, social and cultural costs are only economic costs to the extent that they affect individual and community well-being through direct use of resources by individuals or non-use. If the potential impacts do not occur or are mitigated to the extent where community wellbeing is insignificantly affected (ie those bearing the costs are fully compensated), then no environmental, social or cultural economic costs should be included in the BCA apart from the mitigation, compensation or offset costs.

iv Quantification and valuation of benefits and costs

Consistent with NSW Treasury (2007) guidelines, the analysis has been undertaken in real values with discounting at 7% and sensitivity testing at 4% and 10%. The analysis period is 15 years. Any impacts that occur after the analysis period are included in the analysis as a present value in the final year of the analysis.

Where competitive market prices are available, they have generally been used as an indicator of economic values. Environmental, cultural and social impacts have initially been left unquantified and interpreted using the threshold value method. An attempt has also been made to estimate environmental, cultural and social impacts using market data and benefit transfer. However, even with the inclusion of these values, the estimated net social benefits of the Balranald Project provide a threshold value that any residual or non-quantified economic costs would need to exceed to make the Balranald Project questionable from an economic efficiency perspective.

a. Net production benefits

The following production benefits have been included in the BCA.

Value of minerals

The main economic benefit of the Balranald Project is the market value of the mineral concentrates of zircon, rutile, leucoxene and ilmenite. Both demand and supply of these minerals influences current and projected prices. Iluka has provided its projection of annual revenue that it expects would be generated from the project and this has been included in the analysis. There is uncertainty around future prices (valued in USD) as well as the AUD/USD exchange rate. Iluka has provided a projection of annual revenue that is based on current forecast pricing by an independent consulting company (in US dollars) and an assumed AUD/USD exchange rate.

Residual value of capital equipment and land

The estimated residual value of capital equipment and land was considered for the Balranald Project economic assessment.

b. Net production costs

Opportunity costs of land and capital

There is an opportunity cost associated with using land already owned by Iluka instead of its next best use (ie rural production). However, Iluka advises that all land required for the Balranald Project will be purchased as part of the development costs of the Balranald Project.

As discussed in Chapter 4, Iluka propose to relocate the processing facilities currently located at WRP to the Balranald Project. There is an opportunity cost associated with using this and other equipment that is already in Iluka ownership for the Balranald Project, instead of sale. However, there would only be a limited number of potential purchasers of this equipment for reuse in mineral sand mining operations and given the cost of dismantling and relocating it for use by any prospective purchaser the willingness to pay for it is expected to be modest. An indicator of the opportunity cost of using this equipment in the Balranald Project was estimated using its scrap metal value.

Development costs

Development costs of the Balranald Project are associated with the purchase of equipment, development of the project area, land acquisitions and sustaining capital. These costs include labour costs during the development of the Balranald Project, which reflect the value of labour resources in their next best use.

These development costs include an allowance for environmental mitigation costs including acquisition of land for properties adversely affected by noise and biodiversity offsets. Development costs are included in the economic analysis in the years that they are expected to occur.

Annual operating costs

The operating costs of the Balranald Project include those associated with mine operation, processing of extracted ore, transportation of the HMC and ilmenite, minerals delivery (rail freight and port handling and loading) and general costs (including overheads and administration). These costs include labour costs, which reflect the value of labour resources in their next best use. The Balranald Project's average annual operating costs (excluding royalties) are estimated at 96 M present value.

Rehabilitation and decommissioning costs

At the end of the Balranald Project, the mine site will be rehabilitated and decommissioned over a two to five year period. Rehabilitation and decommissioning costs were included in the assessment based on estimates provided by Iluka.

c. Potential environmental, social and cultural benefits

The Balranald Project will directly employ a large construction and operational workforce over a number of years. Using benefit transfer from studies undertaken on other mining operations (Gillespie Economics 2013) and applying the employment value to the estimated incremental direct employment of the Balranald Project gives an estimated $16 M for the nonmarket employment benefits of the Balranald Project to NSW households. At a regional level the benefit would be $0.2 M.

Gillespie Economics (2013) states that due to the potential for contention about the inclusion of the increased the values of employment, the results have been reported both with and without it.

d. Potential environmental, social and cultural costs

Potential environmental, social and cultural costs have been estimated based on the results of all technical studies. These cost estimates can be seen in Section 3.4.2 of the economic assessment (Appendix P).

v Consolidation of value estimates

The present value of costs and benefits, using a 7% discount rate, is provided in Table 20.8. The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the present value of benefits less the present value of costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the project, because the community as a whole would obtain net benefits from the project.

The Balranald Project is estimated to have total net production benefits of $149 M. Assuming 55% foreign ownership, $132 M of these net production benefits would accrue to Australia. This is the net production benefits of the project minus net profit accruing to the proponent.

The estimated net production benefits that accrue to Australia can be used as a threshold value or reference value against which the relative value of the residual environmental impacts of the Balranald Project, after mitigation, may be assessed. This threshold value is the opportunity cost to society of not proceeding with the project. The threshold value indicates the price that the community must value any residual environmental impacts of the project (be willing to pay) to justify in economic efficiency terms the no development option.

For the Balranald Project to be questionable from an economic efficiency perspective, all incremental residual environmental impacts from the project, that impact Australia, would need to be valued by the community at greater than the estimate of the Australian net production benefits (ie greater than $132 M). This is equivalent to each household in the region valuing residual environmental impacts at $3,270. The equivalent figure for NSW and Australian households is $50 and $16, respectively.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to quantify the residual environmental impacts of the Balranald Project that are associated with mining and transportation within NSW. From Table 20.8 it can be seen that most of the potential impacts are internalised into the operating costs of Iluka Resources via mitigation, offset or compensation, and hence are incorporated into the estimate of net production benefits. Other impacts to Australia are estimated at $1 M, considerably less than the estimated net production benefits of the Balranald Project to Australia.

Overall, the Balranald Project is estimated to have net benefits to Australia of between $132 M and $148 M, and hence is desirable and justified from an economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $123 M and $148 M for the Balranald Project to be questionable from an Australian economic perspective.

Table 20.8 Results of BCA (present values @7% discount rate)

	Costs **Description** **Value ($M)**		**Benefits** **Description** **Value ($M)**
Production	Opportunity cost of land		Value of minerals
	Opportunity cost of capital		Residual value of capital
	Development costs		Residual value of capital
	Operating costs ex royalties		-
	Decommissioning and rehabilitation costs		-
Net production benefits			**$149 ($132)**
Non-market impacts in NSW	Greenhouse gas impacts	$19 ($0)	Non-market values of employment
	Agricultural impacts	Opportunity cost of foregone agriculture included in capital costs (land acquisitions)	-
	Noise impacts	Allowance for acquisition and mitigation measures included in capital costs	-
	Air quality impacts	No material impacts	-
	Surface water	Cost of water included in capital costs	-
	Groundwater	Cost of water and licensing of return flows including in capital costs	-
	Ecology	Some loss of values but offset. Cost of biodiversity offset included in capital costs and operating costs	-

Table 20.8 Results of BCA (present values @7% discount rate)

	Costs Description Value ($M)		Benefits Description Value ($M)
	Road transport impacts	Required road works and road maintenance costs included in the capital and operating costs of the Project	-
	Aboriginal heritage	Unquantified but costs of implementing the recommendations of the archaeological investigations included in capital and operating costs	-
	Non-Aboriginal heritage impacts	No material impacts	-
	Visual impacts	Costs of mitigation included in capital costs of the Project. Residual impacts not material	-
Non-market impacts outside NSW	Material handling and transportation	Unquantified but activities regulated	-
Net social benefits – including employment benefits			**$146 M ($148)**
Net social benefits – excluding employment benefits			**$130 M ($132)**

Note: *Totals may have minor discrepancies due to rounding. When impacts accrue globally, the numbers in brackets relates to the level of impact estimated to accrue to Australia.*

** from an aggregate economic efficiency perspective.*

vi Sensitivity analysis

Uncertainty in a BCA can be addressed through changing the values of critical variables in the analysis (James and Gillespie, 2002) to determine the effect on the NPV. Accordingly, a sensitivity analysis was undertaken on the results of the BCA, where the results were tested for 20% (+ and -) changes to the following variables at a 4%, 7% and 10% discount rate:

- opportunity costs of land;
- opportunity costs of capital equipment;
- development costs;
- operating costs;
- rehabilitation and decommissioning costs;
- mineral value;
- residual value of capital;
- residual value of land; and
- greenhouse costs.

What the analysis indicates is that BCA undertaken at the national level is most sensitive to changes in revenue (reflecting production levels, the value of minerals in USD and the AUD/USD exchange rate) and operating costs, with the former impacting royalties and company tax estimates and the latter impacting company tax estimates only. The analysis is not sensitive to changes in capital costs, opportunity costs of land and capital equipment, decommissioning and rehabilitation cost, residual capital and land costs or environmental costs that have not already been internalised into production costs, such as greenhouse gas costs.

20.3.3 Economic impacts

The focus of regional economic impact assessment is the effect (impact) of a project on the economy in terms of a number of specific indicators of economic activity, such as gross regional output, value-added, income and employment. These indicators can be defined as follows:

- gross regional output – the gross value of business turnover;
- value-added – the difference between the gross regional output and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- income – the wages paid to employees including imputed wages for self-employed and business owners; and
- employment – the number of people employed (including full-time and part-time).

A range of methods can be used to examine the economic impacts of an activity on an economy including economic base theory, Keynesian multipliers, econometric models, mathematical programming models and input-output models (Powell et al., 1985). Gillespie Economics used input-output analysis, consistent with the draft 2002 guideline.

i Input-output analysis

Input-output analysis essentially involves two steps:

- construction of an appropriate input-output table (regional transaction table) that can be used to identify the economic structure of the region and multipliers for each sector of the economy; and
- identification of the initial impact or stimulus of the Balranald Project (construction and/or operation) in a form that is compatible with the input-output equations so that the input-output multipliers and flow-on effects can then be estimated (West, 1993).

ii Economic structure of region

A highly aggregated input-output table for the regional economy in 2011 (refer to Table 4.1 in Appendix P) shows that output for the regional economy is estimated at $16,206 M.

Value-added for the regional economy is estimated at $4,474 M, comprising $1,689 M to households as wages and salaries (including payments to self-employed persons and employers) and $2,785 M in other value-added goods and services imported from outside the region.

The total number of people employed and in the regional economy was 37,689.

The economic structure of the regional economy can be compared with that for NSW through a comparison of results from the respective input-output models. This reveals that the agriculture sectors, trade and accommodation sectors and public/personal services sectors in the regional economy are of greater relative importance than they are to the NSW economy, while the business services sectors are of less relative importance than they are to the NSW economy. The mining sectors, manufacturing sectors, utilities sectors and building sectors are of similar relative importance in the regional and NSW economy.

In terms of output, retail trade, other agriculture and food manufacturing are the most significant sectors to the regional economy. For value-added, the retail trade sectors, other agriculture sectors and the ownership of dwellings sectors are the most significant. The education sectors, retail trade sectors, health sectors, public administration sectors, and community care sectors are the most significant sectors for household income. The retail trade sector, accommodation and restaurants sectors, other agriculture sectors and education sectors are the most significant employer in the regional economy. The food manufacturing sectors and other agriculture sectors are the most significant sectors for regional imports and exports.

iii Economic impact

a. Construction

Given the largely specialist nature of capital equipment and the relatively small size of the regional economy, it has been assumed that all purchases and the leasing of machinery are made outside the regional economy. Thus regional economic activity from the construction phase of the Balranald Project primarily relates to the heavy and civil engineering construction sector and construction services sector.

The average construction workforce required for the Balranald Project during the construction period is 209 (with a peak of 450). Based on the input-output coefficients of the heavy and civil engineering construction sector and construction services sector in the regional economy transactions table (indexed to 2014), approximately $75 M per annum of the development costs would need to be spent in these sectors within the region to result in a direct workforce of 209 people. The direct and indirect regional economic impact of this level of expenditure in the regional economy is reported in Table 20.9.

Table 20.9 Economic impacts of construction on the regional economy

	Direct effect	Production induced	Consumption induced	Total flow on	Total
Output ($'000)	75,422	45,408	15,044	60,452	135,873
Type 11A ratio	1.00	0.60	0.20	0.80	1.80
Value added ($'000)	24,663.4	17,708.8	8,295.2	26,003.9	50,667.3
Type 11A ratio	1.00	0.72	0.34	1.05	2.05
Income ($'000)	12,742	8,179	2,846	11,024	23,766
Type 11A ratio	1.00	0.64	0.22	0.87	1.87
Employment (no.)	209	141	70	211	420
Type 11A Ratio	1.00	0.68	0.33	1.01	2.01

In total, annual impact of construction of the Balranald Project on the regional economy is estimated at up to:

- $136 M in annual direct and indirect regional output or business turnover;
- $51 M in annual direct and indirect regional value added;

- $24 M in annual direct and indirect household income; and
- 420 direct and indirect jobs.

The Type 11A ratio multipliers for the construction phase in the regional economy range from 1.80 for output up to 2.05 for employment.

Flow-on impacts from the construction phase of the Balranald Project are likely to affect a number of different sectors of the local and regional economy. The sectors most impacted by output, value-added and income flow-ons are likely to be construction services, wholesale and retail trade, ownership of dwellings, road transport, heavy and civil engineering construction and food and beverage.

iv Operations

a. Regional economy

The annual economic impacts of the Balranald Project on the regional economy are shown in Table 20.10.

Table 20.10 Economic impact of operations on the regional economy

	Direct effect	Production induced	Consumption induced	Total flow-on	Total
Output ($'000)	618,148	294,752	51,794	346,546	964,694
Type 11A ratio	1.00	0.48	0.08	0.56	1.56
Value added ($'000)	152,657	118,437	28,559	146,996	299,653
Type 11A ratio	1.00	0.78	0.19	0.96	1.96
Income ($'000)	47,438	24,590	9,798	34,388	81,825
Type 11A ratio	1.00	0.52	0.21	0.72	1.72
Employment (no.)	554	496	239	735	1,289
Type 11A Ratio	1.00	0.90	0.43	1.33	2.33

During the operational phase, the Balranald Project is estimated to make up to the following annual contribution to the regional economy:

- $965 M in annual direct and indirect regional output or business turnover;
- $300 M in annual direct and indirect regional value added;
- $82 M in annual direct and indirect household income; and
- 1,289 direct and indirect jobs.

The Type 11A ratio multipliers for the Balranald Project impact on the regional economy range from 1.56 for value-added up to 2.33 for employment.

Flow-on impacts from the Balranald Project are likely to affect a number of different sectors of the regional economy. The sectors most impacted by output, value-added and income flow-ons are likely to be the:

- road transport sector;
- professional, scientific and technical services sector;

- retail trade sector;
- wholesale trade sector;
- electricity supply sector;
- food and beverage sector;
- ownership of dwellings;
- electricity transmission sector;
- residential building sector;
- construction service sector;
- education and training sector;
- building cleaning, pest control, administrative and other support services sector; and
- health care services sector.

b. NSW economy

The annual economic impacts of the Balranald Project on the NSW economy are shown in Table 20.11.

Table 20.11 Economic impact of operations on the NSW economy

	Direct effect	Production induced	Consumption induced	Total flow-on	Total
Output ($'000)	618,148	86,949	15,279	102,228	720,376
Type 11A ratio	1.00	0.14	0.02	0.17	1.17
Value added ($'000)	152,657	34,938	8,425	43,363	196,020
Type 11A ratio	1.00	0.23	0.06	0.28	1.28
Income ($'000)	47,438	7,254	2,890	10,144	57,582
Type 11A ratio	1.00	0.15	0.06	0.21	1.21
Employment (no.)	554	146	71	217	771
Type 11A Ratio	1.00	0.26	0.13	0.39	1.39

The Balranald Project is estimated to make up to the following annual contribution to the NSW economy:

- $720 M in annual direct and indirect regional output or business turnover;
- $196 M in annual direct and indirect regional value added;
- $58 M in annual direct and indirect household income; and
- 771 direct and indirect jobs.

The Type 11A ratio multipliers for the Balranald Project impact on the NSW economy range from 1.17 for output up to 1.39 for employment.

v Other economic impacts

a. Contraction in other sectors

Economic impacts for regional and State economies modelled using input-output analysis represent only the gross or positive economic activity associated with the Balranald Project. Where employed and unemployed labour resources in the region are limited and the mobility of in-migrating or commuting labour from outside the region is restricted there may be competition for regional labour resources that drives up local and regional wages. In these situations, there may be some 'crowding out' of economic activity in other sectors of the regional economy.

Crowding out would be most prevalent if the regional/NSW economy was at full employment and it was a closed economy with no potential to use labour and other resources that currently reside outside the region. However, the regional and State economy are not at full employment and they each have access to external labour resources. Consequently, little crowding out of economic activity in other sectors would be expected as a result of the project.

However, even where there is some crowding out of other economic activities this does not indicate losses of jobs but the shifting of labour resources to higher valued economic activities. This reflects the operation of the market system where scarce resources are reallocated to where they are most highly valued and where society would benefit the most from them. This reallocation of resources is therefore considered a positive outcome for the economy not a negative.

b. Regional economic impacts of displaced agriculture

The Balranald Project will result in a reduction in agricultural activity from:

- the agricultural disturbance area;
- the biodiversity offsets; and
- use of surface water resources.

The potential reduction in agricultural annual output as a result of these impacts were estimated by SLR in the AIS. The direct and indirect regional economic impacts of a reduction in regional agricultural output have been estimated using input-output analysis. A comparison of the regional economic impacts of the Balranald Project and the foregone agricultural production during the Balranald Project operation is provided in Table 21.12. The foregone agricultural regional economic activity impacts are between 0.1% and 0.8 of the regional economic activity impacts of the Balranald Project.

Table 20.12 Regional economic impacts of the Balranald Project and Displaced Agriculture

	Project	Agriculture Land	
	Impact	Impact	% of Project
Annual direct output value ($000)	618,148	748	0.1%
Annual direct value-added ($000)	152,657	410	0.3%
Annual direct income ($000)	47,438	111	0.2%
Direct employment (No.)	554	5	0.8%
Annual direct and indirect output ($000)	964,694	1,228	0.1%
Annual direct and indirect value-added ($000)	299,653	632	0.2%
Annual direct and indirect income ($000)	81,825	190	0.2%
Direct and indirect employment (No.)	1,289	6	0.5%

The BCA included estimation of the present value of production costs and benefits of the Balranald Project. The present value of net production benefits of the Balranald Project to Australia are estimated at $149 M, with in the order of $132 M accruing to Australia. These estimates include an allowance for the opportunity costs of the agricultural land. In contrast, the present value of foregone agriculture in perpetuity is estimated at $4 M.

The net production benefits of the Balranald Project to Australia are therefore 38 times those of displaced agriculture.

c. Wage impacts

In the short-run, increased regional demand for labour as a result of the Balranald Project could potentially result in some increases pressure on wages in other sectors of the economy. The magnitude and duration of this upward wages pressure would depend on the level of demand for additional labour, the availability of labour resources in the region and the availability and mobility of labour from outside the region. Where upward pressure on regional wages occurs it represents economic transfer between employers and owners of skills and would attract skilled labour to the region leading to downward pressure on wages.

vi Mine cessation

As previously outlined, the Balranald Project would stimulate demand in the regional and NSW economy during the construction and operational phases leading to increased business turnover in a range of sectors and increased employment opportunities. Conversely, the cessation of the mining operations in the future could result in a contraction in local, regional and NSW economic activity.

The magnitude of the local and regional economic impacts of cessation of the Balranald Project would depend on a number of interrelated factors at the time, including:

- the movements of workers and their families;
- alternative development opportunities; and
- economic structure and trends in the regional economy at the time.

Ignoring all other influences, the impact of Balranald Project cessation on the local and regional area would depend on whether the workers and their families affected would leave the local and regional area. If it is assumed that some or all of the workers remain in the local and regional area, then the impacts of Balranald Project cessation would not be as severe compared to a greater level leaving the local and regional area. This is because the consumption-induced flow-ons of the decline would be reduced through the continued consumption expenditure of those who stay (Economic and Planning Impact Consultants, 1989). Under this assumption, the regional economic impacts would approximate the direct and production-induced effects in Table 20.10. However, if displaced workers and their families leave the region then impacts would be greater and begin to approximate the total effects in Table 20.10.

The decision by workers, on cessation of the Balranald Project, to move or stay would be affected by a number of factors including the prospects of gaining employment in the local and regional economy compared to other regions, the likely loss or gain from homeowners selling, and the extent of attachment to the local and regional areas (Economic and Planning Impact Consultants, 1989).

To the extent that alternative development opportunities arise in the local and regional economy, the regional economic impacts associated with mining closure that arise through reduced production and employment expenditure can be substantially ameliorated and absorbed by the growth of the region. One key factor in the growth potential of a region is its capacity to expand its factors of production by attracting investment and labour from outside the region (BIE, 1994). This in turn can depend on a region's natural endowments. In this respect, the local and regional area is prospective with other mineral sand resources, including other resources that Iluka has access to.

It is therefore likely that, over time, new mining developments would occur, offering potential to strengthen and broaden the economic base of the local and regional area and hence buffer against impacts of the cessation of individual activities.

Ultimately, the significance of the economic impacts of cessation of the Balranald Project would depend on the economic structure and trends in the local and regional economy at the time. For example, if Balranald Project cessation takes place in a declining economy, the impacts might be significant. Alternatively, if Balranald Project cessation takes place in a growing diversified economy where there are other development opportunities, the ultimate cessation of the Balranald Project may not be a cause for concern.

Nevertheless, given the uncertainty about the future complementary mining activity in the local and regional economy it is not possible to foresee the likely circumstances within which Balranald Project cessation would occur.

20.3.4 Government finance

i Commonwealth

The main financial benefit from the Project to the Commonwealth Government is company tax and income tax from mine employees. Personal income tax from direct employees is estimated at $16 M present value. Company tax was also estimated.

ii State

The main financial benefit of the Balranald Project to NSW is the royalties paid. These are estimated at $96 M present value. In addition, the payroll tax to NSW from the operational employees of the Balranald Project is estimated at $3 M present value.

iii Local

BSC may directly benefit from higher rates on land used for the Balranald Project since rates for mining are generally higher than the land uses that it replaces.

While the Balranald Project will result in some increased demands on local roads, Iluka will negotiate equitable road maintenance agreements with the BSC to proportionally fund the ongoing road maintenance requirements for the council roads affected along the product transport route. Iluka will also contribute to the remedying of a number of existing deficiency is the road network (refer to the transport assessment in Appendix N).

Iluka is committed to entering into an agreement with BSC in relation to Iluka's contributions to and involvement in the local area and has commenced discussions regarding the scope and terms of such an agreement.

20.4 Management and mitigation

The Balranald Project will provide substantial economic benefit to the regional and NSW economies. Accordingly, no mitigation measures are considered necessary.

20.5 Conclusion

The Balranald Project is estimated to have total net production benefits of $148 M. Assuming 55% foreign ownership, $132 M of these net production benefits would accrue to Australia. This is the net production benefits of the project minus net profit accruing to the proponent.

Instead of leaving the environmental, cultural and social impacts unquantified an attempt was made to quantify them. The main quantifiable environmental impacts of the Balranald Project that have not already been incorporated into the estimate of net production benefits via mitigation, offset and compensation costs, relate to greenhouse gas emissions. These impacts to Australia are estimated at less than $ 1M, considerably less than the estimated net production benefits of the Balranald Project. There may also be some non-market benefits of employment provided by the Balranald Project which are estimated to be in the order of $16 M. Overall, the Balranald Project is estimated to have net social benefits to Australia of between $132 M and $148 M and hence is desirable and justified from an economic efficiency perspective.

While the main environmental, cultural and social impacts have been quantified and included in the Balranald Project BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $132 M and $148 M for the Balranald Project to be questionable from an Australian economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $132 M and $148 M for the Balranald Project to be questionable from an Australian economic perspective.

Input-output analysis found that the operation of the Balranald Project is estimated to make up to the following contribution to the regional economy:

- $965 M in annual direct and indirect regional output or business turnover;
- $300 M in annual direct and indirect regional value added;

- $82 M in annual direct and indirect household income; and
- 1,289 direct and indirect jobs.

For the NSW economy, the operation of the Balranald Project is estimated to make up to the following contribution:

- $720 M in annual direct and indirect regional output or business turnover;
- $196 M in annual direct and indirect regional value added;
- $58 M in annual direct and indirect household income; and
- 771 direct and indirect jobs.

While the Balranald Project would result in some displacement of agricultural activity, these economic impacts are estimated at between 0.1% and 0.8% of the regional economic activity benefits of the project.

21 Geochemical

21.1 Introduction

The SEARs require a strategy for the management waste, including overburden and tailings, generated by the Balranald Project. The SEARs state this EIS must include:

> a full description of the development, including:
>
> ...
>
> a waste (overburden, tailings, etc) management strategy, dealing with the EPA's requirements;
>
> Hazards and Risks – including:
>
> - a detailed description of the management of concentrate and backloaded waste material during transport, storage and handling; and

To inform the strategy for the management of waste, a geochemical assessment for the Balranald Project was prepared by Earth Systems (Appendix Q) and the results are summarised in this chapter. The geochemical assessment was also required to inform a number of other assessments to address matters including water management and impacts to water resources. Other studies conducted in parallel with the geochemistry assessment include the water assessment (Appendix K), soil resources assessment (Appendix L), hazard and risk assessment (Chapter 22) and rehabilitation and closure strategy (Appendix M).

The geochemical assessment was undertaken in accordance with the following regulations, methods and guidelines:

- *Leading Practice Sustainable Development Program for the Mining Industry: Managing Acid and Metalliferous Drainage* (Department of Industry, Tourism and Resources 2007);
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000a);
- *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC/ARMCANZ 2000b);
- *Guidelines for Groundwater Protection in Australia* (ANZECC/ARMCANZ 1995);
- *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC 2006);
- *NSW Water Quality and River Flow Objectives* (DECCW 2006);
- *The NSW State Groundwater Policy Framework Document* (Department of Land and Water Conservation 1997);
- *The NSW State Groundwater Quality Protection Policy* (Department of Land and Water Conservation 1998);
- *Guidelines for the Assessment and Management of Groundwater Contamination* (DEC 2007);
- *NSW Waste Classification Guidelines* (DECCW 2009);

- *The NSW Acid Sulfate Soils Assessment Guidelines* (Acid Sulfate Soils Management Advisory Committee 1998);
- *Prediction & Kinetic Control of Acid Mine Drainage* (AMIRA 2002); and
- *Global Acid Rock Drainage Guide* (International Network for Acid Prevention 2010).

21.2 Method

Geochemical test work programs were completed for the Balranald Project. A preliminary geochemical characterisation program was conducted by KCB in 2012 (KCB 2013) and a supplementary geochemical characterisation program and assessment was conducted by Earth Systems in 2014 (Appendix Q).

The supplementary geochemical characterisation program increased the sampling density for geochemical characterisation of the overburden materials and included a detailed assessment of the acid mine drainage (AMD) potential of the dewatered and sulfidic pit walls and benches (in particular, the OOB).

21.2.1 Sampling

A total of 101 samples (73 from the West Balranald deposit and 28 from the Nepean deposit) were analysed for static geochemical test work as part of the preliminary geochemical program to characterise the overburden and ore from 14 locations. Samples from a further three locations were part of the supplementary geochemical characterisation program.

The geochemical test work was conducted on the following samples:

- overburden (including NSOB, SOB and OOB) which allowed for the assessment of AMD risk associated with overburden stockpiles, backfill material and de-saturated pit wall/bench/floor material;
- ore which allowed for the assessment of AMD risk associated with key domains on-site including ore stockpiles and oversize material screened at the MUP; and
- product and mining by-product streams which allowed for the assessment of AMD risk associated with key domains on-site including product and mining by-product stockpiles, ModCoD and backfill material.

Mining by-products and product samples were prepared and supplied by Iluka for classification and included:

- sand tails;
- ModCoD;
- thickener underflow; and
- WHIMS process streams (ilmenite, magnetic rejects and HMC).

Samples of the following mining-by products that would be generated at the Hamilton MSP and potentially transported back to the project area for placement in the mine void were classified in accordance with the *NSW Waste Classification Guidelines*:

- PDC ilmenite;
- combined monazite rejects;
- Hyti (Leucoxene);
- combined zircon wet tails;
- rutile wet concentrate circuit tails;
- PDC conductors oversize (+410 µm); and
- float circuit tails.

21.2.2 Test work

Laboratory test work conducted in the geochemical characterisation programs included:

- mineralogical test work to clarify the distribution of primary sulfides, secondary acid sulfate generating mineral species and carbonate minerals within the ore and overburden;
- static geochemical test work to understand the potential magnitude of AMD risk associated with key materials;
- kinetic geochemical test work to characterise the potential rate of AMD generation associated with key materials; and
- test work to characterise the physical properties and potential reactivity of the key materials and characterise against the EPA guidelines.

The characterisation of the sampling and testing are detailed in Section 21.3.2.

21.3 Existing environment

21.3.1 Hydrogeology

The two key geological formations within the project area are the Shepparton Formation and the Loxton-Parilla Sands, with the ore body hosted in the Loxton-Parilla Sands. The ore body at the West Balranald mine is below the water table, while at the Nepean mine the ore body is either above or straddling the water table. The geology and hydrogeology of the project area are described in Section 3.2, 3.3 and Chapter 14.

21.3.2 Geochemical characterisation

Following sampling and testing, the AMD risk of the materials was assessed. The samples were classified into the following categories outlined in Table 21.1:

- potentially acid forming (PAF):
  - high potential for acid generation;
  - moderate/high potential for acid generation;
  - moderate potential for acid generation;
  - low potential for acid generation;
- non acid forming (NAF):
  - unlikely to be acid generating; and
  - likely to be acid consuming.

Table 21.1 AMD risk classification

General AMD risk classification	Detailed AMD risk classification	Overburden samples				Ore	
		West Balranald			Nepean	West Balranald	Nepean
		NSOB	SOB	OOB	NSOB		
PAF	High potential for acid generation	-	-	6	-	1	-
	Moderate/high potential for acid generation	-	-	-	-	-	-
	Moderate potential for acid generation	-	-	12	-	7	-
	Low potential for acid generation	-	-	34	1	8	-
Total PAF samples		**-**	**-**	**52**	**1**	**16**	**-**
NAF	Unlikely to be acid generating	13	50	1	22	-	5
	Likely to be acid consuming	-	-	-	-	-	-
Total NAF samples		**13**	**50**	**1**	**22**	**-**	**5**

From the results shown in Table 21.1, it can be seen that:

- NSOB and SOB at the West Balranald deposit is generally NAF;
- both the ore and OOB at the West Balranald deposit is PAF; and
- the ore and NSOB overburden at the Nepean deposit is NAF.

21.4 Impact assessment

21.4.1 Methodology

The geochemical characterisation results were used in combination with the Balranald Project's water balance (Section 14.3.4) and groundwater modelling (Section 14.3.6) to assess the potential geochemical impacts of the Balranald Project during construction, operation and post closure.

For each potential impact that could occur from PAF material, the likelihood, consequence and resulting impact rating was assessed with reference to a standard impact assessment matrix developed by Iluka specifically for the Balranald Project (Table 21.4). Residual impact ratings were then determined, taking into account proposed AMD management and mitigation approaches and with consideration of the environmental setting of the project area, which is expected to limit the spatial extent of the Balranald Project's impacts associated with local water quality changes.

The definitions of likelihood and consequence for the risk assessment are detailed in Table 21.2 and 21.3 while Table 21.4 outlines the matrix used to assign impact rating for each potential impact.

Table 21.2 Likelihood definitions

Rating	Description	Likelihood of occurrence	Frequency
A	Almost certain	Recurring event during the life of the mine	Likely to occur more than twice a year
B	Likely	Event that may occur frequently during the life of the mine	Likely to occur once or twice a year
C	Possible	Event that may occur during the life of the mine	Might occur once a decade
D	Unlikely	Event that is unlikely to occur during the life of the mine but may occur following mine closure	Possibility to occur once a century
E	Very unlikely	Event that is very unlikely to occur during the life of the mine and is unlikely to occur following mine closure	Unlikely to occur within a century

Table 21.3 Consequence definition

Rating	Description	Health and safety	Environment	Community	Project interruption	Reputation and image
1	Insignificant	Local treatment with short recovery-minor short term health effects	Onsite release, containable with minimal damage	No damage to external property, infrastructure or water assets	Negligible Critical systems unavailable for less than one hour	Negligible impact
2	Minor	Medical treatment required for short term acute health effects	Major onsite release with some damage, no offsite damage Remediation in terms of days	Minor damage to external property, infrastructure or water assets	Inconvenient Critical systems unavailable for several hours	Adverse local media coverage only
3	Moderate	Lost Time Injury (off work recovery required) or short/medium term health issues	Offsite release, no significant environmental damage Remediation in terms of weeks	Moderate damage to external property, infrastructure or water assets	Critical systems unavailable for less than one day	Adverse capital city media coverage
4	Major	Extensive injuries or chronic health issues	Major offsite release, short to medium term environmental damage to nationally significant ecosystem Remediation in terms of months	Major damage to external property, infrastructure or water assets	Critical systems unavailable for one day or a series of prolonged outages	Adverse and extended national media coverage
5	Catastrophic	Single fatality or permanent disability	Major offsite release, long term environmental damage to nationally or internationally significant ecosystem Remediation in terms of years	Irreparable damage to external property, infrastructure or water assets	Critical systems unavailable for more than a day (at a crucial time)	Demand for government inquiry

Table 21.4 Impact rating matrix

	Consequence				
Likelihood	**1. Insignificant**	**2. Minor**	**3. Moderate**	**4. Major**	**5. Catastrophic**
A. Almost certain	Medium	Medium	High	High	High
B. Probable	Low	Medium	Medium	High	High
C. Possible	Low	Medium	Medium	Medium	High
D. Unlikely	Low	Low	Medium	Medium	High
E. Very unlikely	Low	Low	Low	Medium	Medium

21.4.2 Results

A summary of the potential impacts, management measures and residual impacts of the Balranald Project on groundwater and surface water, relating to the potential for sulfide oxidation and associated AMD generation from mine materials, during the construction, operation and post-closure phases of the development is presented in Table 21.5 to 21.9. Table 21.5 provides a summary of the geochemical overburden impacts, Table 21.6 provides a summary of the geochemical ore impacts, Table 21.7 provides a summary of geochemical mining by-product impacts, Table 21.8 provides a summary of geochemical pit walls, benches and floor impacts, and Table 21.9 provides a summary of geochemical products impacts of the Balranald Project.

The impact ratings are based on estimated AMD generation rates, where available, and the subsequent implications for the receiving environment including water resource use, aquatic ecosystems or riparian land.

Table 21.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Overburden material stockpiled above ground level – West Balranald	Runoff or seepage of AMD from temporary OOB stockpile into surface water/ groundwater	Construction	Major	Probable	High	Confirm field-based method for identification of PAF versus NAF overburden. Routine monitoring and segregation of OOB. Low permeability liner, incorporating limestone, beneath OOB stockpile. Surface water drainage control around OOB stockpile. Minimise surface area of OOB stockpile (relocate to pit as soon as possible). Incorporate sufficient quantity of limestone in OOB stockpile, allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from OOB stockpile. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at MUP dam and OOB stockpile.	Major	Unlikely	Medium
		Operation	n/a	n/a	-	Not required.	n/a	n/a	-
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Overburden material stockpiled above ground level – Nepean	Runoff or seepage of AMD from temporary overburden stockpiles into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Overburden material used for site construction works	Runoff or seepage of AMD from overburden materials used for site construction works into surface water/ groundwater	Construction	Major	Very unlikely	Medium	Avoid use of OOB for site construction works. If any overburden is to be used as a construction material then characterise and classify the material to ensure that it is both NAF and non-saline.	Moderate	Very unlikely	Low
		Operation	Major	Very unlikely	Medium	As above.	Moderate	Very unlikely	Low
		Post-closure	Minor	Very unlikely	Low	As above.	Minor	Very unlikely	Low
Overburden material backfilled in pit - West Balranald	Release of AMD from backfilled overburden into void/groundwater or surface water as a result of sulfide oxidation between the time of OOB dewatering and final inundation below groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Continue routine monitoring and segregation of OOB. Return OOB directly to its final storage location as low as possible in the backfill profile. Rapidly cap (within 1-2 days) backfilled OOB with at least 5 m of SOB or inert clay-rich material. To address any residual acidity, incorporate sufficient quantity of limestone into backfilled OOB, allowing for three times the theoretical neutralisation requirement. Traffic compact backfilled limestone-blended OOB, and cover as soon as practicable. Collect, treat and/or reuse any acidic runoff or seepage from backfilled OOB. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam. Regular groundwater monitoring from dewatering bores.	Minor	Unlikely	Low

Table 21.5 Summary of geochemical overburden impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
		Post-closure	Major	Probable	High	As per operations phase management approach. Monitor the rate of groundwater rebound and bore water chemistry in backfilled OOB until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
Overburden material backfilled in pit - Nepean	As above	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	Major	Unlikely	Medium	More extensive geochemical assessment of overburden materials for the Nepean deposit.	Minor	Very unlikely	Low

Table 21.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Ore material stockpile from West Balranald	Runoff or seepage of AMD from stockpiled ore into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Probable	High	Backfill oversize material directly to West Balranald pit. Backfill oversize material to the pit in the same manner as backfilled OOB. Low permeability liner, incorporating limestone, beneath stockpiled ore. Surface water drainage control around stockpiled ore. Minimise surface area of ore stockpile. Incorporate sufficient quantity of limestone in stockpiled ore, allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from stockpiled ore, as an alternative or in combination with limestone blending (see above). Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at MUP dam and ore stockpile/s.	Major	Unlikely	Medium
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Ore material stockpile from Nepean deposit	As above	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	More extensive geochemical assessment of ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
Process plant water	Uncontrolled release of process plant water affected by AMD from ore material	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	Incorporate bunding around the process plant area and develop an emergency response plan to address the risk of uncontrolled overflow of process water that may be affected by AMD from the ore material.	Moderate	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Pipeline failure while pumping ore slurry from MUP to PCP	Runoff or seepage of AMD from ore slurry into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and ore slurry collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down ore transfer during any bushfire event in the vicinity of the slurry pipeline. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.6 Summary of geochemical ore impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
Transport accident on haul road between Nepean and West Balranald deposits leading to spill of Nepean ore	Runoff or seepage of AMD from Nepean ore into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Unlikely	Low	Recover any spilled ore as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential transport accident involving a spill of ore material. More extensive geochemical assessment of ore materials for the Nepean deposit. Construct internal roads within the project area to minimise interaction between mining equipment and haul trucks, and general light vehicle traffic on site.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
Mining by-products stored above ground level	Release of AMD via supernatant water overflow from TSF to Box Creek	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Possible	Medium	Develop TSF operating protocols to maintain/create sufficient storage to contain the design rainfall event. Incorporate sufficient quantity of limestone in ModCod, allowing for three times the theoretical neutralisation requirement. Routine monitoring and characterisation of ModCod to inform neutralisation requirements. Regular surface water monitoring at TSF. Field-based kinetic geochemical test work (oxygen diffusion profiles) to refine acidity load estimates / neutralisation requirements. Incorporate AMD considerations into TSF emergency response procedures.	Major	Unlikely	Medium
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Seepage of AMD from TSF into groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Possible	Medium	Install clay liner across TSF embankment and floor. Ensure that any seepage is collected and pumped back to the TSF or treated and reused on site. Regular seepage water monitoring at TSF.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
	TSF embankment failure leading to release of sulfidic mining by-products/AMD to surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Unlikely	Medium	TSF design to withstand extreme rainfall/ earthquake events in accordance with ANCOLD guidelines. Develop TSF operating protocols to maintain/create sufficient storage to contain the design rainfall event. Regular surface water monitoring at TSF. Incorporate AMD considerations into TSF emergency response procedures.	Moderate	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Runoff or seepage of AMD from temporary MBPs stockpiles into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Probable	Medium	Transport the Hamilton by-products back to the mine site as frequently as possible to minimise AMD generation at the processing plant and associated neutralisation requirements. Return sand tails, magnetic rejects and Hamilton by-products directly, if possible, to the West Balranald pit. Low permeability liner, incorporating limestone, beneath by-product stockpiles. Consider temporary stockpiling below ground level so drainage reports to the pit sump. Surface water drainage control around stockpiled by-products. Minimise surface area of by-product stockpiles. Incorporate sufficient quantity of limestone in stockpiled by-products, allowing for three times the theoretical neutralisation requirement. Routine monitoring and characterisation of each by-product stream to inform neutralisation	Moderate	Very unlikely	Low

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
	TSF embankment failure leading to release of sulfidic mining by-products/AMD to surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Major	Unlikely	Medium	TSF design to withstand extreme rainfall/ earthquake events in accordance with ANCOLD guidelines. Develop TSF operating protocols to maintain/create sufficient storage to contain the design rainfall event. Regular surface water monitoring at TSF. Incorporate AMD considerations into TSF emergency response procedures.	Moderate	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Runoff or seepage of AMD from temporary MBPs stockpiles into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Probable	Medium	Transport the Hamilton by-products back to the mine site as frequently as possible to minimise AMD generation at the processing plant and associated neutralisation requirements. Return sand tails, magnetic rejects and Hamilton by-products directly, if possible, to the West Balranald pit. Low permeability liner, incorporating limestone, beneath by-product stockpiles. Consider temporary stockpiling below ground level so drainage reports to the pit sump. Surface water drainage control around stockpiled by-products. Minimise surface area of by-product stockpiles. Incorporate sufficient quantity of limestone in stockpiled by-products, allowing for three times the theoretical neutralisation requirement. Routine monitoring and characterisation of each by-product stream to inform neutralisation	Moderate	Very unlikely	Low

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
						mining by-products and cover with SOB as soon as practicable. Collect, treat and/or reuse any acidic runoff or seepage from backfilled mining by-products. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam.			
		Post-closure	Major	Probable	High	As per operations phase management approach (most of these measures listed above are intended to not only address operational phase risks but also to pre-emptively manage the potential post-closure impacts. Monitor the rate of groundwater rebound and pore water chemistry in backfilled mining by-products until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
mining by-product pipelines	Failure of mining by-products pipeline	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and slurry collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down mining by-product transfer during any	Minor	Unlikely	Low

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	Impact	Phase	Conseq.	L'hood	Impact		Conseq.	L'hood	Impact
						bushfire event in the vicinity of the pipelines. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.			
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Return water pipeline	Failure of return water pipeline	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Possible	Medium	Install bunding and return water collection sump(s) along the pipeline alignment. Clear vegetation along pipeline alignment and ensure fire control systems are in place before commencing pipeline operation. Install isolation valves along pipeline. Shut-down return water transfer during any bushfire event in the vicinity of the pipeline. Install a pipeline leak detection system. Regular pipeline maintenance and inspection. Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for potential pipeline failure.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.7 Summary of geochemical mining by-product impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Hamilton by-product transport to West Balranald mine for final disposal	Transport accident (off site) leading to release into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for transport accident involving a spill of mining by-products.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
Mining by-product transport on site	Transport accident (off site) leading to release into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Unlikely	Low	Recover any spilled material as soon as practicable. Incorporate AMD considerations into emergency response procedures for transport accident involving a spill of mining by-products.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.8 Summary of geochemical pit walls, benches and floor impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
In-situ pit wall, bench and floor material that is unsaturated due to mine dewatering – West Balranald	Release of AMD from dewatered in situ material into void/ groundwater or surface water	Construction	Major	Possible	Medium	Collect, treat and/or reuse any acidic runoff or seepage from box cut wall, bench and floor. Direct any AMD affected groundwater from mine dewatering to treatment plant, if required. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at box cut sump and MUP dam. Routinely monitor groundwater chemistry during dewatering.	Minor	Unlikely	Low
		Operation	Major	Possible	Medium	Where overburden is exposed in bench lags, maintain a layer of in situ SOB as long as possible (eg. minimum 5 m) before disturbing OOB. Incorporate sufficient quantity of limestone into backfilled overburden to address AMD generation from in situ materials (in addition to backfill), allowing for three times the theoretical neutralisation requirement. Collect, treat and/or reuse any acidic runoff or seepage from pit wall, bench and floor. Direct any AMD affected groundwater from mine dewatering to treatment plant, if required. Incorporate AMD considerations into MUP dam design, operation and emergency response procedures. Regular surface and groundwater monitoring at pit sump and MUP dam. Routinely monitor groundwater chemistry during dewatering.	Minor	Unlikely	Low

Table 21.8 Summary of geochemical pit walls, benches and floor impacts from the Balranald Project

Potential impacts						Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
		Post-closure	Major	Probable	High	As per operations phase management. Monitor the rate of groundwater rebound and pore water chemistry until the final groundwater level has been achieved, to confirm that sufficient neutralising capacity has been added to prevent residual acid salts from contaminating the groundwater system. Use dewatering bores to facilitate post-closure monitoring of groundwater rebound, prior to full decommissioning.	Moderate	Unlikely	Medium
	Release of AMD from dewatered in situ material into groundwater injection aquifer	Construction	Minor	Unlikely	Low	Routinely monitor groundwater chemistry during dewatering and injection, to confirm that receiving groundwater in the injection aquifer will not be adversely affected.	Minor	Unlikely	Low
		Operation	Minor	Unlikely	Low	As per construction phase management approach.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Failure of pipeline between dewatering and injection sites	Construction	Minor	Unlikely	Low	Not required.	Minor	Unlikely	Low
		Operations	Minor	Unlikely	Low	Not required.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
In-situ pit wall, bench and floor material that is unsaturated due to mine dewatering – Nepean	Release of AMD from dewatered in situ material into void/ groundwater/ surface water due	Construction	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden and ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Operations	Moderate	Unlikely	Medium	More extensive geochemical assessment of overburden and ore materials for the Nepean deposit.	Minor	Very unlikely	Low
		Post-closure	Moderate	Unlikely	Medium	Not required.	Minor	Very unlikely	Low

Table 21.9 Summary of geochemical product impacts from the Balranald Project

	Potential impacts					Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Mining products – during temporary storage at West Balranald process plant	Runoff or seepage of AMD from stockpiled HMC product into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operation	Minor	Possible	Medium	Low permeability liner, incorporating limestone, beneath HMC product stockpile. Surface water drainage control around HMC product stockpile. Minimise surface area of HMC product stockpiling. Frequent transport of mining products off site. Collect, treat and/or reuse any acidic runoff or seepage from HMC product stockpile. Regular surface and groundwater monitoring at HMC product stockpile.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Runoff or seepage of AMD from stockpiled ilmenite product into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Minor	Possible	Medium	As per HMC product stockpile during operations phase.	Minor	Very unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

Table 21.9 Summary of geochemical product impacts from the Balranald Project

	Potential impacts					Iluka's proposed management approach	Residual impacts		
Element	**Impact**	**Phase**	**Conseq.**	**L'hood**	**Impact**		**Conseq.**	**L'hood**	**Impact**
Mining products – during off site transport	Transport accident (off site) leading to release of HMC product and subsequent runoff or seepage of AMD from spilled material into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into transport accident emergency response procedures.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-
	Transport accident (off site) leading to release of ilmenite product and subsequent runoff or seepage of AMD from spilled material into surface water/ groundwater	Construction	n/a	n/a	-	Not required.	n/a	n/a	-
		Operations	Moderate	Unlikely	Medium	Recover any spilled material as soon as practicable. Incorporate AMD considerations into transport accident emergency response procedures.	Minor	Unlikely	Low
		Post-closure	n/a	n/a	-	Not required.	n/a	n/a	-

21.4.3 Analysis

The highest risk potential and residual impacts during the three phases of the Balranald Project are as follows:

- during the construction phase of the Balranald Project, the highest risk AMD impact, and key residual impact, is runoff or seepage of AMD from temporary OOB stockpile into surface water or groundwater;
- during the operations phase of the Balranald Project, the highest risk AMD impacts, and key residual impacts, are:
  - runoff or seepage of AMD from stockpiled ore at the West Balranald site into surface water or groundwater; and
  - release of AMD from the TSF to Box Creek.
- Post closure and decommissioning of the Balranald Project, the highest risk AMD impacts, and key residual impacts, are:
  - release of AMD from backfilled overburden at West Balranald into the final void or groundwater;
  - release of AMD from backfilled mining by-products at West Balranald below the final groundwater level, into the final void or groundwater; and
  - release of AMD from dewatered in situ material at West Balranald into the final void or groundwater.

21.5 Management and mitigation

A range of measures outlined in Tables 21.5 to 21.9 are proposed to manage and mitigate AMD risks associated with the Balranald Project. The key measures include:

- routine monitoring and segregation of OOB during mining;
- installation of a low permeability/limestone liner beneath OOB stockpiles during excavation of the initial boxcut and stockpiled ore;
- incorporate sufficient quantity of limestone in OOB stockpile liner during excavation of the initial boxcut and stockpiled ore;
- surface water drainage control around the OOB stockpiles during excavation of the initial boxcut and stockpiled ore;
- minimise the amount and surface area of stockpiled OOB (ie relocate to pit as soon as possible) and ore;
- incorporate AMD considerations into MUP dam design, operation and emergency response procedures;

- return OOB directly (via the in-pit haulage routes) to its final storage location as low as possible in the backfill profile below the final (natural) groundwater level in the West Balranald mine;
- rapidly (within 1-2 days) cap backfilled OOB with at least 5 m of SOB or inert clay-rich material sourced from the aquitard separating the Shepparton and Loxton-Parilla Sands Formations;
- incorporate sufficient quantity of limestone into backfilled OOB and mining by-products, allowing for three times the theoretical neutralisation requirement to address AMD from both backfilled and in situ sources, during the operations phase;
- transport compact backfilled limestone-blended overburden and cover as soon as practicable;
- backfill oversize material directly to the West Balranald mine void;
- routine monitoring and characterisation of mining by-products to inform neutralisation requirements;
- no disposal of mining by-products at the Nepean mine;
- co-dispose thickener underflow and sand tails as ModCoD (as described in Section 4.6), to facilitate handling and trafficability of backfilled material;
- return mining by-products from Hamilton MSP directly if possible to their final placement location in the West Balranald mine backfill profile however if this is not possible:
    - stockpile by-products on low permeability pads comprising a limestone liner with surface water drainage control at the MUP site; or
    - alternatively, consider temporary stockpiling of by-products below ground level so that drainage reports to the pit sump;
- transport compacted backfilled limestone-blended mining by-products and cover as soon as practicable;
- regular surface and groundwater monitoring at the pit sump, MUP dam, OOB and ore stockpiles;
- where OOB is exposed in benches in the pit, maintain a layer of in situ SOB as long as possible (eg minimum 5 m) before disturbing OOB; and
- collect, treat and/or reuse any acidic runoff or seepage from OOB stockpiles and stockpiled ore, backfilled OOB, backfilled mining by-products and pit walls/benches/floor.

As demonstrated in Tables 21.5 to 21.9, following implementation of these management and mitigation measures, residual risks were generally found to be low and manageable throughout the three project phases.

21.6 Conclusion

Samples from the West Balranald and Nepean deposits were analysed to characterise the overburden and ore as part of the Balranald Project's geochemical assessment. Mining by-products that would be generated at the Hamilton MSP and product samples were also classified as part of the assessment. The results of the assessment indicate that the NSOB and SOB at the West Balranald deposit is NAF, while the ore and OOB is PAF. At the Nepean deposit, both the ore and NSOB is NAF.

The results were used in conjunction with the water balance estimates and groundwater modelling to assess potential water quality impacts and the quantity of AMD generated from overburden, ore, mining by-products, pit walls, benches and floors and products. As a result of this assessment the highest risk AMD impacts were considered to be:

- during construction phase - runoff or seepage of AMD from temporary OOB stockpile into surface water or groundwater;
- during operations phase - runoff or seepage of AMD from stockpiled ore at the West Balranald mine into surface water or groundwater and release of AMD from the TSF to Box Creek; and
- post closure and decommissioning - release of AMD from backfilled overburden, mining by-products and dewatered in situ material at the West Balranald mine into the final void or groundwater.

A range of measures are proposed to manage and mitigate AMD risks associated with the Balranald Project. Following implementation of these management and mitigation measures, residual risks were generally found to be low and manageable throughout the three project phases.

22 Hazard and risk

22.1 Introduction

The SEARs require an assessment of potential hazards and risks of the Balranald Project. The SEARs state that the EIS must address:

> Hazards and Risks – including:
>
> - a detailed description of the management of concentrate and backloaded waste material during transport, storage and handling; and
> - bushfires.

The management of concentrate (HMC and ilmenite) and back-loaded waste is addressed in Chapter 21 and this chapter. Chapter 21 provides details on the potential hazards and risks associated with the AMD characteristics of mine materials, including products and by-products, and provides details on the management and mitigation measures that would be implemented to reduce these hazards and risks to acceptable levels.

This chapter provides details on the potential hazards and risks associated with radioactive mine materials, including products (HMC and mineral concentrates) and by-products, and provides details on the management and mitigation measures that would be implemented to reduce these hazards and risks to acceptable levels. It is based on a radiation risk assessment prepared by Iluka which can be found in Appendix S.

In addition, this chapter provides an assessment on the storage of dangerous goods within the project area, such as diesel, petrol, other hydrocarbons in accordance with Applying SEPP 33.

A bushfire assessment is contained in Chapter 23.

22.2 Radioactive mine materials

22.2.1 Introduction

The radiation risk assessment was prepared utilising baseline soil and water radiation assessments by Earth Systems and Land & Water Consulting (LWC). The key objectives of the radiation risk assessment was to:

- describe and characterise sources of radiation and identify current levels of radiation at the project area;
- determine if any materials (soils, groundwater and by-products) are classified as radioactive; and
- assessing and transport activities.

The radiation risk assessment was prepared in accordance with relevant legislation, guidelines and polices, including but not limited to:

- RC Act;

- POEO Act;
- *NSW Waste Classification Guidelines* (EPA 2014);
- *Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)* (the Code) (ARPANSA 2005);
- *1990 Recommendations of the International Commission on Radiological Protection* (ICRP), *ICRP Publication 60* (ICRP 1991);
- *Australian Drinking Water Guidelines* (National Health and Medical Research Council 2015); and
- *Guidelines for Drinking-water Quality, 4th edition* (World Health Organisation 2011).

22.2.2 Existing environment

The main heavy mineral constituents of mineral sands are the titanium-bearing minerals, predominately ilmenite, but also rutile and leucocoxene, zircon, and the rare earth bearing minerals, monazite and xenotime. The relative proportion of these minerals varies from deposit to deposit, but ilmenite contributes by far the largest proportion of the heavy mineral constituents, commonly about 50 to 70%.

As stated in Chapter 2, the combined Measured, Indicated and Inferred Resource of the West Balranald deposit (excluding Nepean) contains 12.0 Mt of heavy mineral with an average assemblage of 10.8% zircon, 11.9% rutile and 64.1% ilmenite. The combined Indicated and Inferred Resource reported for the Nepean deposit contains 2.4 Mt of heavy mineral with an average assemblage of 14.4% zircon, 14.5% rutile and 59.7% ilmenite.

Uranium and thorium are also present in these minerals. The concentrations of uranium and thorium are generally in trace amounts except for monazite, which typically contains 5% to 7% thorium and 0.1% to 0.3% uranium.

Consequently, the mining and processing of heavy mineral ores has the potential to cause elevated radiation exposures of both workers and the public during operations and from the management of waste arising from production. Therefore, depending on the level of potential exposure, certain radiation control measures may be required to provide for an adequate degree of protection for both employees and the public.

In general, radiation hazards to workers arise in the mining and processing of heavy minerals through three principal pathways, namely external irradiation, inhalation and ingestion. The specific potential exposure pathways are:

- external exposure from the ore body during mining of ores or during separation of heavy minerals, or from stockpiled ore or mineral concentrates;
- external exposure during transport of ore or mineral concentrates;
- internal exposure from the inhalation of dust containing elevated levels of radioactivity;
- internal exposure from the inhalation of radon gas released from minerals during mining and processing operations or from stockpiled material; and
- direct ingestion of material during handling of ores and heavy mineral concentrates and products.

Potential exposure pathways to members of the public include off-site releases of dusts or radon gas, contamination of food and water supplies due to the migration of radionuclides from the mine site during mining operations or following the disposal of tailings. Radioactivity associated with the various heavy minerals or tailings may also have the potential to be dispersed in the environment during processing operations.

22.2.3 Impact assessment

i Radiation standards and limits

The risks associated with radiation are mostly known and quantified. The objective of radiation protection is to limit the exposure to radiation by the application of comprehensive programs of measurements of all significant radiation sources to ensure that no employee or member of the public are exposed to levels exceeding those prescribed by legislation.

The premier international body for radiation protection is the ICRP. The radiation limits recommended by the ICRP have generally been adopted around the world, including in Australia in Commonwealth, state and territory legislation. The recommended dose limits have changed over time as more information on the health effects of radiation has become available. However there has been only one major change to the recommended limits to worker in the past 50 years, in the *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991).

Radiation standards and limits contained within *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991) are shown in Table 22.1.

Table 22.1 Dose limits for occupational exposed persons and members of the public

Application	Dose limit - occupational exposed person	Dose limit - members of the public
Effective dose	20 mSv per year averaged over a period of 5 consecutive calendar years [4,5,6]	1 mSv in a year [7]
Equivalent dose to:		
• lens of the eye	20 mSv per year averaged over a period of 5 consecutive calendar years [4,5,6]	15 mSv in a year
• skin [8]	500 mSv in a year	50 mSv in a year
• the hands and feet	500 mSv in a year	No limit specified

Notes *1. The limit apply to the sum of the relevant doses from external exposure in the specified period and the committed dose from intakes in the same period. In this Note, committed dose means the dose of radiation, arising from the intake of radioactive material accumulated by the body over 50 years following the intake (except in the case if intakes by children, where it is the dose accumulated until the age of 70).*

2. Any dose resulting from medical diagnosis should not be taken into account.

3. Any dose attributable to normal naturally occurring background levels of radiation should not be taken into account.

4. With the further provision that the effective dose must not exceed 50mSv in a single year.

5. When a female employee declares a pregnancy, the embryo or foetus should be afforded the same level of protection as a member of the public.

6. When, in exceptional circumstances, a temporary change in the dose limit requirements is approved by the Authority, one of the following conditions applies:

- *The effective dose limit must not exceed 50mSv per year for the period, that must not exceed 5 years, for which the temporary change is approved, and*
- *The period for which the 20mSv per year average applies must not exceed 10 consecutive years and the effective dose must not exceed 50mSv in any single year.*

7. In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1mSv per year

8. The equivalent dose limit for the skin applies to the dose averaged over any 1 square centimetre of skin, regardless of the total area exposed.

The doses received may be averaged over five years, but the dose to a worker in any one year must not exceed 50 millisieverts (mSv). These limits apply to total dose received from operational sources including external gamma exposure and inhalation of radon decay products and dust (with the doses from natural background being excluded).

There are no exposure limits for the individual dose components. Likewise there are also no specific dose limits set for shorter periods (less than a year). This is because the likely health effects depend only on the total dose accumulated over a long period (possibly decades). In an operational situation, investigation and action levels are set for each pathway at levels that ensure continued exposure will not lead to doses above these long-term limits.

Details on radiation standards and limits can be found in the radiation risk assessment in Appendix S.

ii Classification of materials

Three 'materials' were considered by Iluka to determine the risk of radiation exposures to both workers and the public as a result of the Balranald Project. This included the risk of exposure to mine materials, groundwater and mining by-products. Mine materials include all soils, including the ore, which will be mined as part of the project.

a. Mine materials

Earth Systems undertook a preliminary assessment of the radioactive properties and behaviour of mine materials (overburden, wastes and ore) from the West Balranald deposit. The mine materials were sampled during a sonic drilling and core extraction program of the existing in-situ mine materials from 25 June to 1 July 2014. The sample program was designed to collect information on five distinctive soil lithologies, as follows:

- surface soils (SS);
- NSOB;
- SOB;
- OOB; and
- ore.

The results of this analysis can be seen in Table 22.2.

Table 22.2 Radiation analysis for mine materials

Radionuclide results (Bq/g)	Soil lithologies				
	SS	NSOB	SOB	OOB	Ore
U (ppm)	4.4±0.2	4.8±0.2	1.5±0.1	11.2±0.3	45.0±0.6
U (Bq/g)[#]	0.055	0.060	0.019	0.139	0.56
Th(ppm)	7.8±0.7	15±1	4.5±0.5	5.1±0.4	310±20
Th (Bq/g)[@]	0.032	0.061	0.018	0.021	1.258
Th-232 decay chain					
Th-232	0.031±0.003	0.059±0.005	0.018±0.002	0.021±0.002	1.25±0.09
Ra-228	0.033±0.004	0.058±0.006	0.020±0.002	0.010±0.001	1.3±0.1
Th-228	0.034±0.003	0.057±0.006	0.017±0.002	0.013±0.001	1.3±0.1
U-238 decay chain					
U-238	0.055±0.003	0.060±0.003	0.019±0.002	0.139±0.004	0.538±0.008
Th-230	< 0.11^	< 0.12^	<0.062^	< 0.57^	0.7±0.1
Ra-226	0.022±0.002	0.042±0.004	0.013±0.001	0.015±0.002	0.57±0.06
Pb-210	< 0.017	0.054±0.006	0.022±0.004	< 0.0084	0.46±0.05
Po-210[*]	0.32±0.04	0.064±0.04	0.021±0.04	0.047±0.04	0.22±0.04
U-235 decay chain					
U-235&	0.0025&	0.0028&	0.00087&	0.0064&	0.026±0.005
Pa-231	< 0.036	< 0.036	< 0.026	< 0.020	< 0.044
Ac-227	< 0.0067	< 0.0064	< 0.0046	< 0.0041	< 0.031
Th-227	< 0.0067	< 0.0064	< 0.0046	< 0.0041	< 0.031
Potassium-40					
K-40	0.34±0.03	0.61±0.06	0.14±0.01	0.13±0.01	0.14±0.01
Total contained activity[ǂ]	**1.5**	**1.9**	**0.57**	**1.0**	**20.9π**

Notes: ** Po-210 concentration on the count date of 19 September 2014.*

^ No gamma peak was detected in the gamma spectrum. Less than values quoted are statistically determined by the gamma analysis software.

& No gamma peak was detected in the gamma spectrum. U-235concentration calculated from the measured U-238 concentration.

ǂ Including K-40. Less than values assume zero concentration for those particular radionuclides in the calculations.

π Assumes the concentration of Po-210 is 0.56Bq/g.

ǂ Includes the contribution from all radionuclides (long- and short-lived) in each of the respective decay chains and K-40. Less than values assume zero concentration for those particular radionuclides in the calculation.

Based on the results of the analysis of the samples, Iluka undertook a classification of all mine materials in accordance with the RC Act and POEO Act. The results of the classification can be seen in Table 22.3.

Table 22.3 Classification of mine materials

Results	SS	NSOB	SOB	OOB	ORE
U (ppm)	4.4	4.8	1.5	11.2	45
Weight % U	0.0004	0.0005	0.0002	0.0011	0.0045
Th (ppm)	7.8	15	4.5	5.1	310
Weight % Th	0.0008	0.0015	0.0005	0.0005	0.0310
Weight% U/0.02	0.022	0.024	0.0075	0.056	0.225
Weight% Th/0.05	0.0156	0.03	0.009	0.0102	0.62
U/0.02 + Th/0.05	0.0376	0.054	0.0165	0.0662	0.845
Radioactive ore?	No	No	No	No	No
Total contained activity‡	1.5	1.9	0.57	1	20.9
Radioactive substance?	No	No	No	No	No

The results show that none of the mine materials at West Balranald mine, including the ore, exceed the radioactive classifications thresholds for ores or substances under the RC Act and POEO Act. As such, all mine materials are not classified as radioactive.

Further details on the classification of mine materials can be found in the radiation risk assessment in Appendix S.

b. Groundwater

LWC undertook pre-mining radiation groundwater monitoring at the project area, at both the West Balranald and Nepean deposits, between 2 and 5 June 2014. A number of bores were sampled in the Loxton-Parilla Sands, including bores near the ore bodies, bores up and down gradient of the ore bodies and bores within the extent of mining. The results of the analysis for the West Balranald and Nepean deposits can be seen in Tables 22.4 and 22.5, respectively.

Table 22.4 Summary of radiation analysis for West Balranald bores

Analyte	Near the ore body			Up-hydraulic gradient		Mining extent/down hydraulic gradient			
	WB28	WB40	WB41	GW036868(2)	GW036673(2)	WB5	WB17	WB20(1)	WB20(2)
Naturally occurring u-238 series (Bq/L)									
U-238		<0.02	<0.02			<0.02		2.6	2.7
Th-234	<0.17	<0.13	<0.15	<0.14	<0.45	<0.43	0.12	2.2	
Ra-226	0.104	0.091	0.123	0.109	0.06	0.151	1.82	0.5	
Pb-210	<0.16	<0.13	<0.13	<0.15	<0.6	<0.4	<0.17	<0.61	
Po-210	<0.013			0.0124	0.0034		0.0054		
Naturally occurring thorium series (Bq/L)									
Th-232		0.01	0.014			<0.005		<0.005	<0.005
Ra-228	0.325	0.194	0.297	0.206	0.189	0.298	0.683	1.72	
Th-228	<0.039	<0.029	<0.036	<0.037	<0.039	<0.038	<0.030	<0.034	

Table 22.4 Summary of radiation analysis for West Balranald bores

Analyte	Near the ore body			Up-hydraulic gradient		Mining extent/down hydraulic gradient			
	WB28	WB40	WB41	GW036868(2)	GW036673(2)	WB5	WB17	WB20(1)	WB20(2)
Naturally occurring uranium radioisotopes (Bq/L)									
U-238	0.053			0.012	0.0099		0.0509		
U-235	0.0113			0.00105	<0.0017		0.0055		
U-234	0.083			0.012	0.0109		0.0569		
Naturally occurring thorium radioisotopes (Bq/L)									
Th-232	<0.013			<0.0034	<0.0019		<0.0045		
Th-230	0.036			0.0261	0.0212		0.0157		
Th-228	0.019			0.0112	0.0128		0.0189		
Th-227	0.022			<0.0071	<0.017		<0.0086		

Table 22.5 Summary of radiation analysis for Nepean bores

Analyte	Near the ore body		Up-hydraulic gradient		Mining extent/down hydraulic gradient	
	N10	GW036790(2)	GW036674(1)	GW036866(2)	N7	N28
Naturally occurring u-238 series (Bq/L)						
U-238				<0.02		<0.02
Th-234	<0.18	<0.13	0.09	<0.14	<0.47	<0.45
Ra-226	0.114	1.87	0.082	<0.053	0.202	1.064
Pb-210	<0.16	<0.14	<0.13	<0.14	<0.61	<0.42
Po-210	<0.0044	0.025	0.0131		0.0081	
Naturally occurring thorium series (Bq/L)						
Th-232				<0.005		<0.005
Ra-228	0.194	0.162	0.097	<0.14	0.185	0.472
Th-228	<0.032	<0.034	<0.017	<0.033	0.036	<0.043
Naturally occurring uranium radioisotopes (Bq/L)						
U-238	0.0568	0.151	0.0136		0.0358	
U-235	0.0046	0.0174	0.0025		0.0027	
U-234	0.066	0.154	0.0134		0.0609	
Naturally occurring thorium radioisotopes (Bq/L)						
Th-232	0.0054	<0.0095	0.0038		<0.0036	
Th-230	0.0172	0.035	0.021		0.00243	
Th-228	0.0099	<0.0098	0.0109		0.0049	
Th-227	<0.008	0.017	<0.006		<0.0076	

Key findings of the groundwater radiation monitoring are as follows:

- With respect to human health screening (ie ingestion of water), only one water sample (sampled from WB20) exceeded the Australian Drinking Water Guidelines (ADWG) dose threshold of 1 mSv per year, largely driven by uranium-238, andradium-228 from the thorium series.

- Radium 228 appears to be generally elevated in all waters sampled, relevant to the World Health Organisation's (WHO) radium-228 screening criterion for drinking waters of 0.1 becquerel per litre (Bq/L).

Notwithstanding the above activity levels, the water sampled (in the Loxton-Parilla Sands) is not suitable for potable use due to salinity levels.

Further details on the classification of groundwater can be found in the radiation risk assessment in Appendix S.

c. Mining by-products

Earth Systems undertook a laboratory test-work program to classify mining by-products that would be produced at the Hamilton MSP in accordance with the EPA's *Waste Classification Guidelines*. Samples of each of the by-product streams were prepared at Iluka's pilot scale metallurgical test facility based on HMC prepared using West Balranald ore. All samples were submitted for radionuclide and chemical analyses. The by-product streams analysed included:

- primary dry circuit (PDC) ilmenite;
- combined monazite reject;
- HyTi;
- combined zircon wet tails;
- rutile wet circuit concentrate;
- float tails; and
- PDC conductors oversize (+ 410 microns).

Table 22.6 summarises the results of the analysis of the mining by-products.

Table 22.6 Summary of radiation analysis for mining by-products

Radionuclide results (Bq/g)	PDC ilmenite	Combined monazite reject	HyTi	Combined zircon wet tails	Rutile wet circuit concentrate	Float tails sample	PDC conductors
Th-232DecayChain							
Th-232	0.22	77	1.3	0.56	1	0.3	0.89
Ra-228	0.22	68	1.2	0.3	0.91	0.27	0.86
Th-228	0.19	75	1.3	0.3	0.9	0.27	0.86
U-238DecayChain							
U-238	0.11	14	0.42	1.01	0.58	0.48	0.81
Th-230	0.12	17	0.5	0.78	0.51	<0.3	0.9
Ra-226	0.12	13	0.47	0.83	0.58	0.39	0.82
Pb-210	0.14	13	0.42	0.72	0.47	0.33	0.68
Po-210	0.03	8	0.34	0.3	0.16	0.25	0.31

Table 22.6 Summary of radiation analysis for mining by-products

Radionuclide results (Bq/g)	PDC ilmenite	Combined monazite reject	HyTi	Combined zircon wet tails	Rutile wet circuit concentrate	Float tails sample	PDC conductors
U-235DecayChain							
U-235	0.0051	0.65	0.0194	0.0466	0.0268	0.0222	0.037
Pa-231	<0.026	0.8	<0.069	<0.039	<0.043	<0.064	<0.13
Ac-227	<0.0053	1	0.028	0.046	0.03	0.019	0.047
Th-227	<0.0053	1	0.028	0.045	0.03	0.019	0.047
Potassium-40							
K-40	0.026	<0.32	0.1	<0.024	0.07	<0.044	0.3
Total contained activity‡	**3.7**	**938**	**19.4**	**15.7**	**17.2**	**8.2**	**20.5**
Specific activity - Group 1	1.7	460	9.3	7.0	8.1	3.5	9.5
Specific activity - Group 2	1.6	375	7.9	6.4	7.0	3.5	8.5
Specific activity - Group 3	0.32	89	1.8	1.2	1.5	0.7	1.7
Specific activity - Group 4	0.12	15	0.4	1.1	0.6	0.5	0.8

Notes: ‡ IncludingK-40. Less than values assume zero concentration for those particular radionuclides in the calculations.

Based on the results of the analysis of the samples, Iluka undertook a classification of all by-products in accordance with the *NSW Waste Guidelines* and RC Act. The results of the classification can be seen in Table 22.7.

Table 22.7 Classification of by-products

Radionuclide results (Bq/g)	PDC ilmenite	Combined monazite reject	HyTi	Combined zircon wet tails	Rutile wet circuit concentrate	Float tails sample	PDC conductors
Total contained activity	3.7	938	19.4	15.7	17.2	8.2	20.5
Radioactive Substance	No	Yes	No	No	No	No	No
Specific Activity - Group 1	1.7	460	9.3	7.0	8.1	3.5	9.5
Specific Activity - Group 2	1.6	375	7.9	6.4	7.0	3.5	8.5
Specific Activity - Group 3	0.32	89	1.8	1.2	1.5	0.7	1.7
Specific Activity - Group 4	0.12	15	0.4	1.1	0.6	0.5	0.8
Specific Activity Ratio	1.9	498	10.1	7.7	8.8	3.8	10.3
NSW Waste Guideline Classification	Restricted solid	Hazardous	Restricted solid	Restricted solid	Restricted solid	Restricted solid	Restricted solid
RC Act radioactive substance	No	Yes	No	No	No	No	No

As Table 22.7 shows, with the exception of the combined monazite reject, all of the by-products produced at the Hamilton MSP are likely to be classified as restricted solid waste under the *NSW Waste Guidelines*. The combined monazite reject is likely to be classified as hazardous waste.

Further details on the classification of by-products can be found in the radiation risk assessment in Appendix S.

iii Radiation dose delivery pathways

Potential radiation dose delivery pathways for employees and members of the public resulting from the Balranald Project would include:

- irradiation by gamma radiation;
- inhalation of dusts containing long lived alpha emitting radionuclides (LLAE);
- inhalation of the decay products of radon (radon-222 and radon-220); and
- ingestion of radionuclides.

These potential dose delivery pathways could occur during the following project activities:

- handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine; and
- transporting (via road) of HMC, mineral concentrates and by-products between Balranald Mine and Hamilton MSP.

In addition, there is a risk that an incident or accident resulting in the loss of containment of HMC, mineral concentrates, by-products (eg accident along the transport route) could potentially result in local contamination of land or surface waters.

A discussion of the potential impacts at each of these components is provided below.

a. Handling and stockpiling at Balranald Mine

In the absence of management measures, the long-term accrual of radiation dose (via irradiation, inhalation and/or ingestion) of employees and/or members of the public during the handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine could cause potential doses in excess of the limits contained within *1990 Recommendations of the International Commission on Radiological Protection*, *ICRP Publication 60* (ICRP 1991) (Table 22.1).

Table 22.8 provides a summary of the potential activities and associated dose delivery pathways that would potentially occur at Balranald Mine. Management of HMC, mineral concentrates and by-products at Balranald Mine would be undertaken in accordance with the management and mitigation measures described in Table 22.8. With the implementation of these measures, the risk of harm to employees, members of the public and the environment from the handling and stockpiling of the HMC, mineral concentrates and by-products would be negligible.

Table 22.8 Potential dose delivery pathways of handling and stockpiling at Balranald Mine

Activity	Potential dose delivery pathway	Management and mitigation measures
Handling and stockpiling HMC, mineral concentrates and by-products	• Inhalation or ingestion of LLAE in dust during handling and stockpiling activities • Doses of gamma radiation through close proximity to the mineral concentrates and by-products	• Radiation monitoring program • Stockpile management standard • Radiation management standard • Dust suppression measures • Radioactive waste management plan
Loading of mineral concentrates onto haulage vehicles	• Inhalation or ingestion of LLAE in dust during loading activities • Doses of gamma radiation through close proximity to the mineral concentrates	• Radiation monitoring program • Stockpile management standard • Radiation management standard • Dust suppression measures • Transport management plan
Unloading of by-products from haulage vehicles	• Inhalation or ingestion of LLAE in dust during unloading activities • Doses of gamma radiation through close proximity to the by-products	• Radiation monitoring programme • Stockpile management standard • Radiation management standard • Dust suppression measures • Radioactive waste management plan • Transport management plan
Mixing of by-products with sand residues and coarse rejects.	• Inhalation or ingestion of LLAE in dust through activities associated with loading by-products prior to mixing • Doses of gamma radiation through close proximity to the by-products	• Radiation monitoring program • Dust suppression measures • Radioactive waste management plan
Deposition of blended by-products	• Very little risk of either gamma radiation or dust generation as the blended process waste is wet and material has been blended with non-radioactive material	• Radiation monitoring program • Radioactive waste management plan
Incident or accident resulting in loss of containment of material	• Inhalation of LLAE in dust or doses of gamma radiation • Environmental exposure to radioactive material	• Emergency response plan • Emergency response procedures • Radioactive waste management plan • Transport management plan

b. Transportation

Table 22.9 provides a summary of the potential activities and associated potential dose delivery pathways that would potentially occur during transport of HMC, mineral concentrates and by-products. Management of the transport of HMC, mineral concentrates and by-products for the Balranald Project would be undertaken in accordance with the management and mitigation measures described in Table 22.9. With the implementation of these measures, the risk of harm to employees, members of the public and the environment from the transport of mineral concentrates and MSP process waste would be negligible.

Table 22.9 Potential dose delivery pathways of transportation

Activity	Potential dose delivery pathway	Management and mitigation measures
Transport of HMC, mineral concentrates and MSP process waste	• Doses of gamma radiation through close proximity to the road haulage vehicles and rail wagons containing HMC, mineral concentrates or by-products	• Covering of truck tubs • Haul truck operator training • Contractor management standard • Radiation monitoring program • Radioactive waste management plan • Transport management plan
Wind blown dust during the transport of HMC, mineral concentrates and MSP process waste	• Inhalation or ingestion of LLAE in dust dispersed from haulage vehicles or rail wagons • Doses of gamma radiation through close proximity to the HMC, mineral concentrates or by-products • Environmental exposure to radioactive material	• Covering of truck tub • Haul truck operator training • Contractor management standard • Radiation monitoring program • Emergency response procedures • Radioactive waste management plan • Transport management plan
Incident or accident resulting in loss of containment of HMC, mineral concentrates or MSP process waste	• Inhalation or ingestion of LLAE in dust or doses of gamma radiation following loss of intended containment of material as a result of collision, failure of containment component, or interference by unauthorised personnel • Environmental exposure to radioactive material	• Emergency response plan • Emergency response procedures • Radioactive waste management plan • Transport management plan

c. Environment

An incident or accident resulting in the loss of containment of HMC, mineral concentrates, by-products or blended process waste (eg accident along the transport route) could potentially result in local contamination of land or surface waters. However, in the event of a loss of containment event, there would be limited radiological consequences, as the heavy nature of the radioactive material (ie monazite) and its insolubility in water, would limit the potential for dispersal and therefore the extent of contamination. The coarse heavy nature of the radioactive material would also limit the potential for the material to become airborne. In addition, the radioactive waste management plan and transport management plan would include a plan for dealing with incidents, accidents and emergencies to respond to these events in order to limit the potential for land and surface water contamination.

It is generally accepted that by achieving adequate protection of human health, an acceptable level of protection will be afforded to the environment. Given that the Balranald Project is expected to achieve human health exposure criteria, it is considered that there would be no significant radiological impact on the environment.

22.2.4 Management and mitigation

Management and mitigation measures for the management of radioactive materials at the Balranald Project have been detailed in Tables 22.8 and 22.9 and above. These measures include the preparation and implementation of the following:

- handling and stockpiling of HMC, mineral concentrates and by-products at Balranald Mine:
  - radiation monitoring program;
  - stockpile management standard;
  - radiation management standard;
  - dust suppression measures;
  - emergency response plan;
  - emergency response procedures;
  - radioactive waste management plan;
  - transport management plan;
- transport of HMC, mineral concentrates and by-products:
  - covering of truck tubs;
  - haul truck operator training;
  - contractor management standard;
  - radiation monitoring program;
  - emergency response procedures;
  - emergency response plan;
  - radioactive waste management plan;
  - transport management plan; and
- environment;
  - all measures described above.

These management and mitigation measures would be detailed in an over-arching radiation management plan (RMP) that would be prepared in accordance with the Code (ARPANSA 2005). The RMP would include details of best practicable technology to minimise potential occupational and member of public doses, and would describe monitoring proposed for the Balranald Project.

Further details on the measures proposed to manage and mitigate potential radiation risks associated with the Balranald Project can be found in the radiation risk assessment in Appendix S.

22.2.5 Conclusion

Based on the existing environment baseline information collected for the Balranald Project, waste characterisation work and results from the radiological risk assessment, it is considered that with the implementation of the identified mitigation measures, the Project will present a negligible radiological risk to human health and the environment.

22.3 Storage of dangerous goods

22.3.1 Introduction

An assessment of the storage of dangerous goods was undertaken in accordance with the provisions of SEPP 33. As stated in Chapter 4, while the mining of mineral sands is not identified as a potentially hazardous or offensive industry in SEPP 33, the Balranald Project may be determined to be a potentially hazardous development if the storage of dangerous goods exceeds the thresholds of Applying SEPP 33.

Potential quantities of hazardous materials to be stored and used on-site were compared to the threshold quantities of dangerous goods in Applying SEPP 33.

The bulk hazardous materials that the Balranald Project will use are diesel, petrol, other hydrocarbons (oils, greases, degreaser and kerosene) and liquefied petroleum gas (LPG) and/or liquefied natural gas (LNG). These materials will be stored at a number of locations with appropriate setback distances to site boundaries described in the following sections.

The assessment also considers:

- the *Australian Da*ngerous Goods Code (ADGC) (National Transport Commission 2014);
- Australian Standard 1940:2004 The storage and handling of flammable and combustible liquids (AS 1940:2004) (Standards Australia 2004); and
- Australian Standard/New Zealand Standard 1596:2008 The storage and handling of LP Gas (AS/NZS 1596:2008) (Standards Australia 2008).

22.3.2 Diesel

A diesel storage and refuelling facility will be provided within the processing area, adjacent to the maintenance yard. The facility will provide for the earthmoving fleet, heavy haulage vehicles and mobile equipment.

AS 1940:2004 classifies diesel as a combustible liquid (Class C1). However, diesel is not classified as a dangerous good under the ADGC as its flash point is above 60°C.

Diesel will be stored and handled on-site in accordance with AS 1940:2004.

22.3.3 Petrol

Petrol will be stored and handled on-site for light vehicles, mobile equipment and portable machinery. It will be stored in the same area as the diesel storage and refuelling facility.

Petrol is classified as a Class 3 flammable liquid under the ADGC. The quantities and setback requirements for the storage of on-site would comply with the thresholds specified in Applying SEPP (refer to Figure 22.1). Quantities are measured in tonnes and distances are measured from the storage to a site boundary. For the purposes of the Balranald Project, the boundary is defined as the boundary of the storage and refuelling facility. For example, based on Applying SEPP 33, quantities of 100 t of Class 3 flammable liquid are required to be setback a distance of at least 10 m to the site boundary, and a distance of about 30 m for quantities of 1,000 t.

Petrol will be stored and handled on-site in accordance with AS 1940:2004.

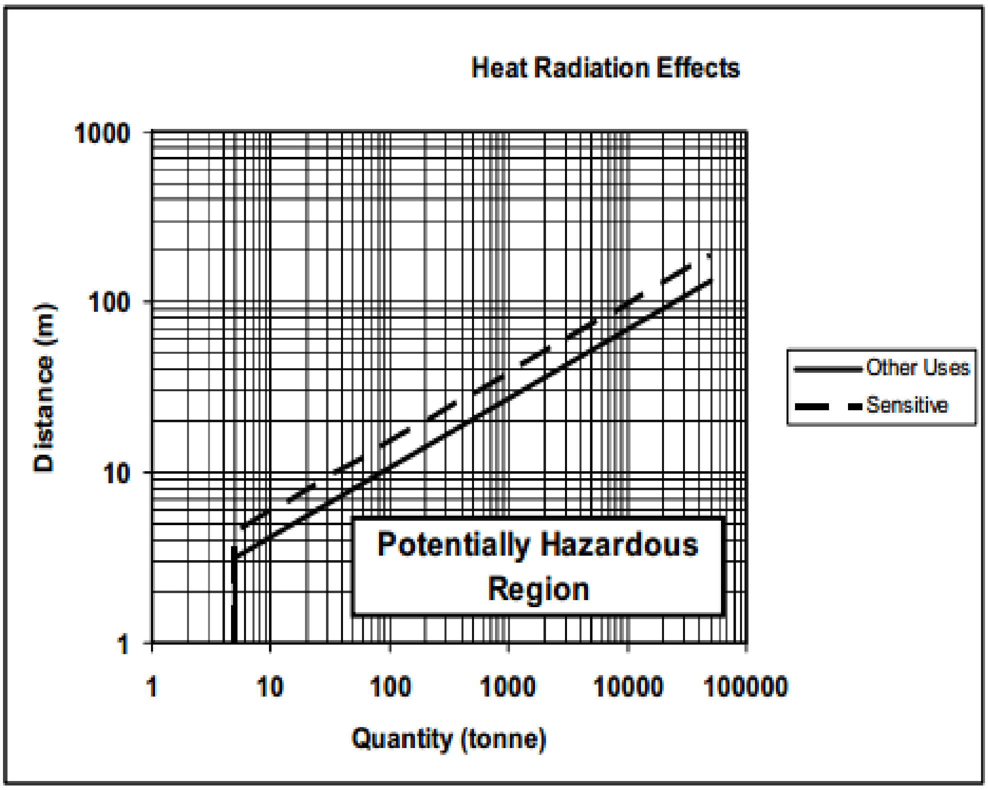


Figure 22.1 SEPP 33 criteria for Class 3 PGII and PGIII flammable liquids (DP&I 2011c)

22.3.4 Other hydrocarbons

Other hydrocarbons including grease, degreaser, kerosene and oil will be used at the Balranald Project. Oil is classified as a Class 3 flammable liquid under the ADGC. The quantities of hydrocarbons including grease, degreaser, kerosene and oil will retain appropriate setbacks to site boundaries specified in Applying SEPP 33. As stated above, based on Applying SEPP 33, quantities of 100 t of Class 3 flammable liquid required a distance to site boundary of at least 10 m.

Hydrocarbons will be stored and handled in accordance with AS 1940:2004. Waste hydrocarbons will be stored in bunded areas and collected by licensed waste contractors for off-site disposal.

22.3.5 Liquid petroleum gas

An on-site gas supply is required to provide fuel for the ISP. The gas supply will be either LPG or LNG and will be delivered to site by tanker, with a dedicated tanker unloading facility, and stored in above ground gas tanks in the processing area near the ISP. The gas supply to the ISP will be via a buried pipeline.

The ADGC classifies LPG and LNG as a Class 2.1 flammable gas. The quantities of LPG or LNG stored will be less than the SEPP 33 potentially hazardous threshold quantity of 10 t (DP&I 2011c). LPG or LNG will be stored in accordance with AS/NZS 1596:2008.

22.3.6 Mitigation and management

Dangerous goods would be sited and stored in accordance with the following measures:

- petrol and oil storages would be sited to comply with the setback requirements specified in Applying SEPP;
- all hydrocarbons, including diesel, petrol and oils will be stored and handled on-site in accordance with AS 1940:2004; and
- LPG or LNG will be stored in accordance with AS/NZS 1596:2008.

Leading up to closure of the Balranald Project, a preliminary sampling and analysis program would be implemented to determine whether a contamination assessment is required for the dangerous goods storage areas.

22.3.7 Conclusion

Hazardous materials were identified and would comply with threshold quantities and distances to site boundaries specified in DP&E's guideline Applying SEPP 33. Subject to these setbacks being maintained and provided that dangerous goods such as diesel, petrol oils and LPG/LNG are stored in accordance with relevant standards, the Balranald Project will not be a hazardous or offensive development.

23 Bushfire

23.1 Introduction

The SEARs for the Balranald Project require an assessment of hazards and risks associated with bushfires. It states:

> Hazards and Risks – including:
>
> ...
>
> - bushfires.

The assessment was undertaken in accordance with the following regulations, methods and guidance documents:

- RF Act;
- Guide for Bush Fire Prone Land Mapping (RFS 2014);
- Lower Western Zone Bushfire Risk Management Plan (RFS 2009); and
- PBP guidelines (RFS 2006).

This chapter presents the results of the bushfire assessment.

23.2 Existing environment

23.2.1 Bushfire prone land

Vegetation on and surrounding the project area comprises a mix of Category 1 vegetation, Category 2 vegetation and excluded vegetation. Category 1 and Category 2 vegetation generally defines what land is considered to be bushfire prone.

Category 1 vegetation is defined under the RFS's *Guide for Bush Fire Prone Land Mapping – V4C-0914* as:

- areas of forest, woodlands, heaths (tall and short), forested wetlands and timber plantations; and
- remnant and short fire run vegetation within 30 m of each other where the combined area is greater than 2.5 ha.

Category 2 vegetation is defined as:

- grasslands, fresh water wetlands, semi-arid woodlands, arid shrublands and rainforests; and
- remnant vegetation and short fire runs greater than 100 m lateral separation from Category 1 vegetation and 30 m from other Category 2 vegetation.

Excluded vegetation includes:

- single areas of vegetation less than 1 ha in area and greater than 100 m separation from other areas of Category 1 or Category 2 vegetation;
- multiple areas of vegetation less than 0.25 ha in area and not within 30 m of each other;
- strips of vegetation less than 20 m in width, regardless of length and not within 20 m of other areas of Category 1 or Category 2 vegetation;
- areas of 'managed grassland' including grassland on, but not limited to, grazing land, recreational areas, commercial/industrial land, residential land, airports/airstrips, maintained public reserves and parklands, commercial nurseries and the like;
- areas of managed gardens and lawns within curtilage of buildings, and botanical gardens;
- non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops;
- agricultural lands used for annual and/or perennial cropping, orchard, market gardens, nurseries and the likes; and
- mangroves Category 1 and Category 2 vegetation, and the buffer that separates Category 1 and Category 2 vegetation from excluded vegetation on and surrounding the project area can be seen in Figure 23.1.

Category 1 and Category 2 vegetation on and surrounding the project area is generally classified as semi-arid woodland and arid shrubland in accordance with the PBP guidelines.

23.2.2 Lower Western Zone Bushfire Risk Management Plan

The RFS's Lower Western Zone Bushfire Management Committee has prepared a bushfire risk management plan for the Lower Wester Zone which covers Balranald LGA (RFS 2009). The plan identifies community assets at risk from bushfire and describes treatment measures for those assets. There are no community assets identified in the plan in or adjacent to the project area. The nearest assets identified are the Homebush Hotel and a radio tower on the Balranald-Ivanhoe Road.

23.3 Impact assessment

23.3.1 Scope of assessment

While SSD is exempt from the need to conform with the specifications and requirements of the RFS's PBP guidelines, they have been considered in this bushfire assessment.

The PBP guidelines focus on protection of habitable buildings on bushfire prone land from bushfire. Habitable buildings are defined in accordance with the Building Code of Australia and include Class 1, 2, 3 and 4 buildings which are primarily used as residences, Class 5, 6, 7 and 8 buildings which are shops, warehouses, factories, offices and car parks and the like, and Class 9 buildings which include health care, community assembly buildings and aged care buildings.

The Balranald Project has two areas where habitable buildings would be constructed; the processing area and the accommodation facility. However, while the processing area is located on bushfire prone land, the accommodation facility is not (refer to Figure 24.1). Therefore, this bushfire hazard assessment focuses on the processing area.

Habitable buildings would only be located in the central part of the processing area, to the south east of the TSF. These include the administration facility and workshop (refer to Figure 4.11).

23.3.2 Assessment method

Bushfire risks have been assessed in accordance with the PBP guidelines and the requirements of the RF Act. The aim of the PBP guidelines is:

> ... to use the NSW development assessment system to provide for the protection of human life (including firefighters) and to minimise impacts on property from the threat of bushfire, while having due regard to development potential, on-site amenity and protection of the environment (RFS 2006).

The objectives of the PBP guidelines are to:

- afford occupants of any building adequate protection from exposure to a bushfire;
- provide for a defendable space to be located around buildings;
- provide appropriate separation between a hazard and buildings which, in combination with other measures, prevent direct flame contact and material ignition;
- ensure that safe operational access and egress for emergency service personnel and residents is available;
- provide for ongoing management and maintenance of bushfire protection measures, including fuel loads in the asset protection zone (APZ); and
- ensure that utility services are adequate to meet needs of fire-fighters (and other assisting in bushfire fighting).

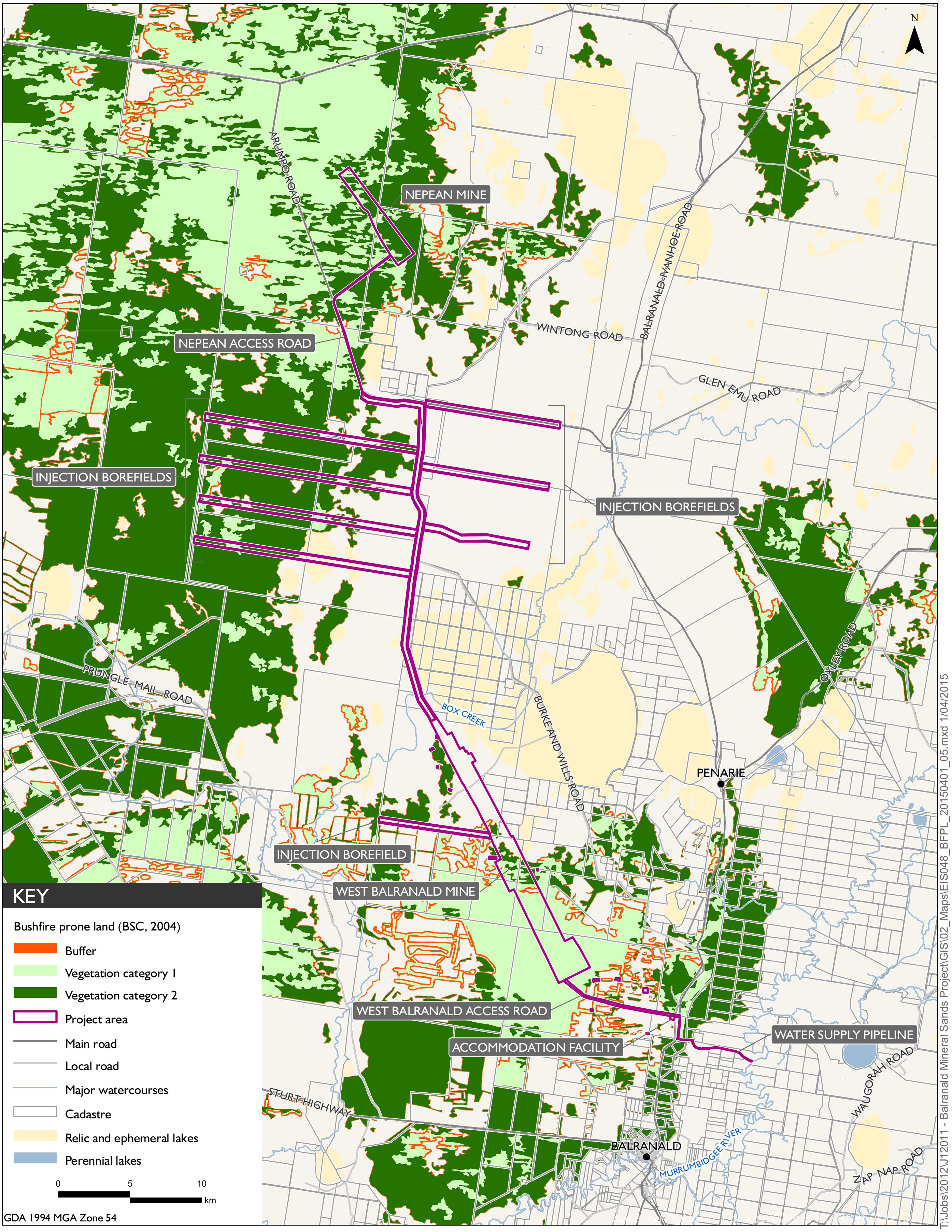
In addition, the RF Act requires the owners of land to prevent the ignition and spread of bushfires on their land.

Bushfire hazard at the processing area has been assessed, and management and mitigation measures described, in accordance with Appendix 4 of the PBP guidelines (submission requirements for DAs on bushfire prone land). The recommended management and mitigation measures in Section 23.4 would aim to ensure that:

- human life, including fire-fighters, is protected;
- impacts on property from the threat of bushfire are minimised; and
- the risk of bushfire ignition and spread would be as low as practically possible.

Recommended bushfire mitigation and management measures for other infrastructure in the project area are based on the PBP guidelines and the DP&E's requirements for other recent mining projects.

APZs, maintenance requirements and specifications for service and access provision were determined in accordance with the PBP guidelines.



EMM ILUKA

Bushfire prone land

Balranald Mineral Sands Project
Environmental Impact Statement
Figure 23.1

23.3.3 Type of development

Generally the Balranald Project would be categorised in section 1.1 of the PBP guidelines as 'other development'. That is, development which is not a residential/rural residential subdivision, residential infill development (new houses or additions to new houses in existing subdivisions) or 'special fire protection purposes' (SFPP) development. Notwithstanding this, the RFS has requested proponents of other recent mining projects in regional NSW (ie Cobbora Coal Project) to consider project buildings and infrastructure as SFPP development when undertaking bushfires assessments. SFPP development is defined under section 100b of the RF Act as developments designed for occupants that are more vulnerable to bush fire attack, including seniors living accommodation, tourist facilities and schools. Therefore, thus category was applied in undertaking this assessment.

23.3.4 Asset protection zones

As with all rural areas, there is a risk that bushfire could occur in or near the project area. Therefore, there is a risk that a bushfire could damage buildings and infrastructure and present a hazard to human life in the project area.

Buildings in developments for the purposes of SFPP are considered to be more vulnerable to bushfire attack. In a mine context, this is because such buildings could contain flammable and other hazardous materials. Heat flux, or thermal flux, is defined as the rate of heat energy transfer through a given surface, per unit surface. The RFS recommends that a heat flux of not more than 10 kilowatt per square metre (kW/m^2) at the facade of such a structure should be achieved during a bush fire to reduce risks (RFS 2006). The provision of APZs are a means of achieving this goal.

An APZ provides a building set back from bushfire hazard vegetation. APZs provide fire vehicle access, reduce radiant heat, reduce convection winds, reduce ember attack and allow smoke to disperse. APZs are divided into an inner protection area (IPA) and an outer protection area. However, in accordance with the PBP guidlines only an IPA is required for semi-arid woodlands and arid shrublands.

APZs were determined using the PBP guidelines which compares the PBP bushfire hazard vegetation classification and slope classes on bushfire prone land to derive minimum APZs. The vegetation communities and slope classes area were characterised in accordance with Appendix 4 of the PBP guidelines.

i Vegetation

Keith (2004) compiled broad scale native vegetation classifications and maps between 2001 and 2004 for NSW (the Keith formations). The PBP guidelines use the Keith formations to classify bushfire hazard vegetation (the PBP classifications). The bushfire hazard classification of native vegetation was determined based on the PBP classifications and vegetation survey results for the project area (refer to Chapter 12).

Vegetation communities and their PBP classifications in and near the processing area are shown in Table 23.1 and Figure 23.2. Based on Table A2.1 in the PBP guidelines, the predominant bushfire hazard vegetation formations (PBP classification) are arid shrublands and semi-arid woodlands.

Table 23.1 Vegetation classifications

Surveyed vegetation communities	PBP classifications
Belah-pearl bluebush woodland	Semi-arid woodlands
Black box grassy open woodland	Semi-arid woodlands
Chenopod sandplain mallee woodland	Semi-arid woodlands
Derived native grassland	Semi-arid woodlands
Flat open claypan/derived sparse shrubland	Arid shrublands
Pearl bluebush low open shrubland	Arid shrublands
Spinifex dune mallee woodland	Semi-arid woodlands

Arid shrublands are dominated by drought tolerant shrubs and occur where soil moisture is too low to support tree dominated vegetation communities. Trees in semi-arid woodlands are 5 m to 20 m tall and have widely spaced canopies. These woodlands are dominated by sclerophyllous trees. Drought resistant shrubs and ephemeral grasses and herbs are also common. Slope.

Slope is an important contributor to a bushfire's rate of spread. A bushfire will spread quicker up a steep slope compared to a gradual slope or flat land. Slopes are classified according to the PBP, and are combined with vegetation classes in an area to determine appropriate APZs.

Slopes in, and for 100 m around, the processing area were determined using a digital terrain model (1 m height resolution). The slopes were classified according to the PBP guidelines (classes (i) to (v)):

(i) all upslope vegetation (considered 0°);

(ii) >0 to 5° downslope vegetation;

(iii) >5 to 10° downslope vegetation;

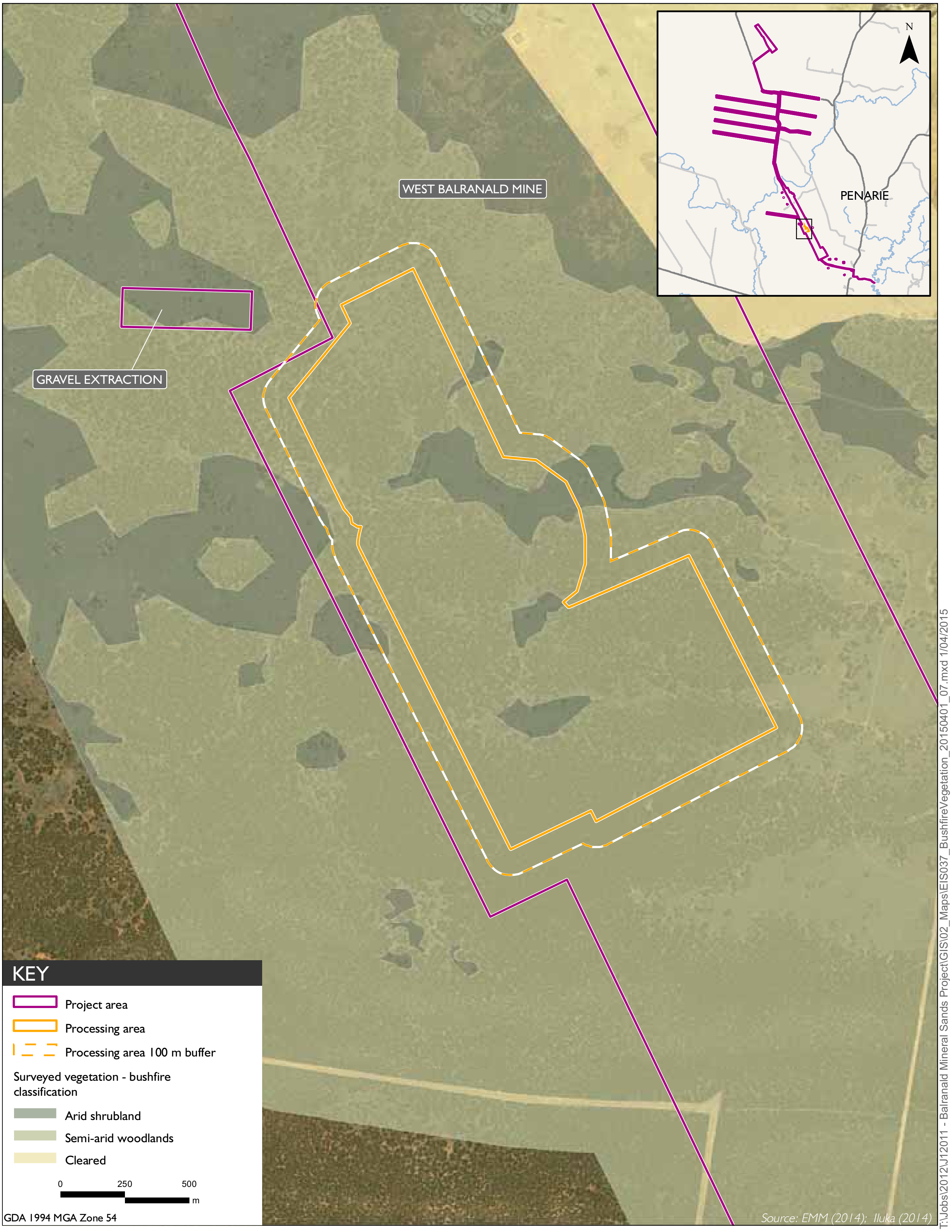
(iv) >10 to 15° downslope vegetation; and

(v) >15 to 18° downslope vegetation.

The slope classes for 100 m around the processing area were calculated using the edge of the processing area as a reference point. The slope classes in the processing area were calculated assuming that any slopes are 'downslope', that is, they slope down from any given building, which presents the greatest bushfire risk. However, if buildings are placed at the base of these slopes during detailed design, their slope class will change from those described below to (i), if they are not already this class. The slope classes relative to building locations will be re-calculated during detailed design.

The topography of the processing area is relatively flat, with only the two lowest PBP slope classes represented: class (i), which applies to any vegetation upslope of a point or with a slope of 0°; and class (ii), which applies to any vegetation greater than 0° and up to 5° downslope of a point.

Figure 23.3 shows details of slope in and surrounding the processing area.



Bushfire hazard vegetation near the processing area

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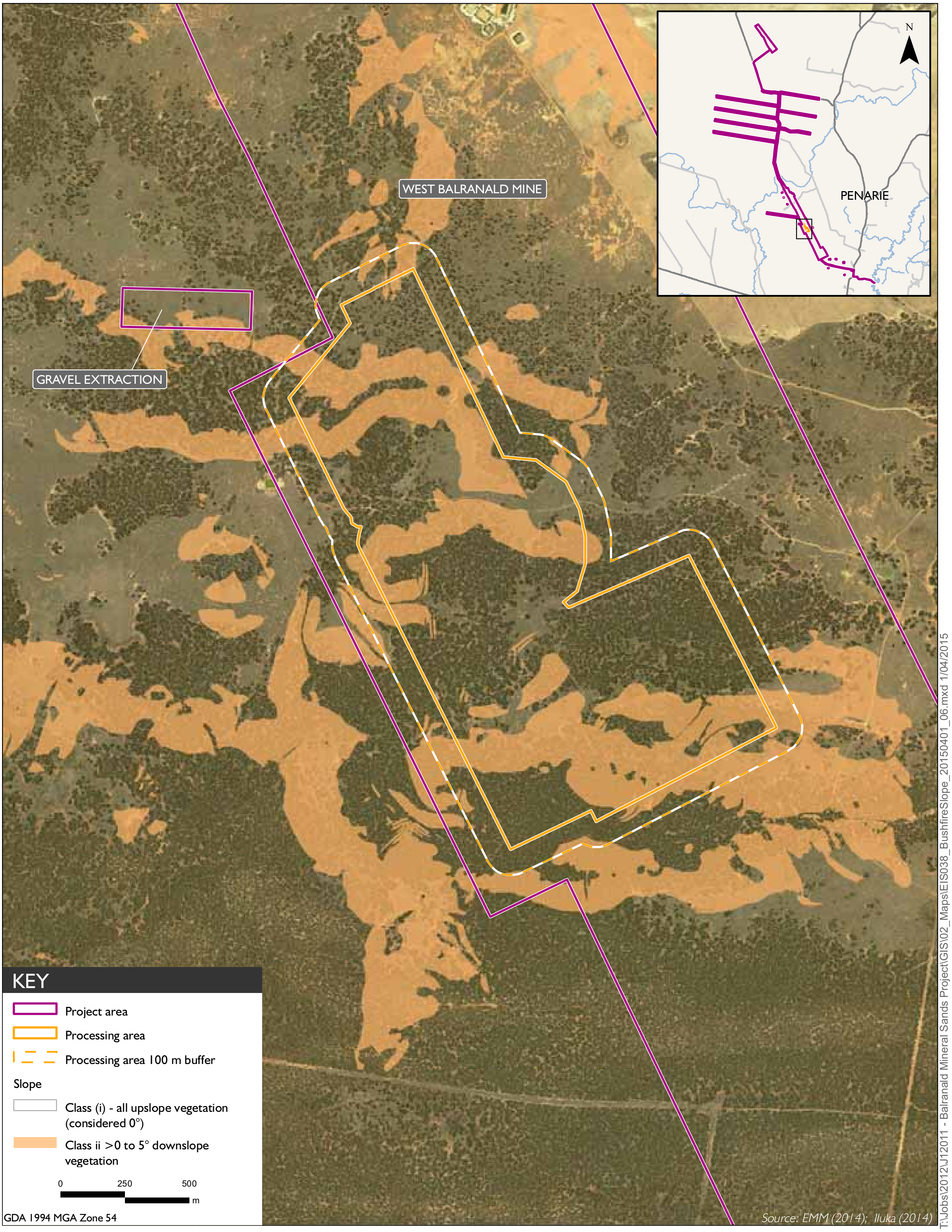
Environmental Impact Statement
Figure 23.2



Slope near the processing area

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Figure 23.3

ii Required asset protection zones

Based on the above, APZs for the processing area are required to be 30 m or 35 m, depending on building locations, and be managed as IPAs. The higher APZ (35 m) is required for buildings which straddle two APZ zones. An APZ of 30 m is required for infrastructure which would not accommodate people.

23.3.5 Results

i Processing area

It is proposed to clear all vegetation in and around the processing area to the disturbance boundary, which for the processing area is the same as the project boundary. The habitable buildings within the processing area would have an APZ of at least 300 m or greater. All infrastructure in the processing area would have an APZ greater than 30 m.

ii Accommodation facility

The accommodation facility is located outside of a 100 m buffer from Category 1 vegetation as per the mapping of bushfire prone land. No buildings would be constructed within this buffer.

23.4 Management and mitigation

To ensure that human life, including fire-fighters, is protected, impacts on property from the threat of bushfire are minimised, and the risk of bushfire ignition and spread will be as low as practically possible, a range of management and mitigation measures would be implemented by Iluka both during the construction and operational phases of the Balranald Project.

The potential for project-related activities to ignite a bushfire would be considered in the detailed design, construction and operation. A bushfire management plan would be prepared that would describe measures to minimise the risk of bushfire-related damage or ignition of a bushfire. The primary management measures are described below.

Protection measures for electricity and gas services, provision of water for firefighting and access to and within the project area would be in accordance with the PBP guideline. Water, gas and electricity services would be located and installed in a manner that minimises fire hazard.

23.4.1 Hazard reduction

The bushfire management plan would contain a strategy for hazard reduction, including hazard reduction in undeveloped areas where vegetation may regenerate.

23.4.2 Water

The availability of water is a critical element in the control of a bushfire, and would be provided as follows:

- the site water management system would provide water for firefighting; including from a dedicated fire water storage tank at the processing area, as well as other water sources (eg non-saline water storage dam);
- water carts may be fitted with water cannons to help with firefighting or other suitable mobile fire fighting equipment will be provided on site; and

- fire hydrants at buildings would be spaced, sized and pressured in accordance with *Australian Standard 2419.1 - 2005 Fire Hydrant Installations – System Design, Installation and Commissioning*.

23.4.3 Electricity and gas

The risk of bushfire to electricity and gas supplies in the project area, and the risk these could ignite a bushfire or contribute to the consequences of a bushfire, would be minimised through the following:

- where operationally practical, electrical transmission lines would preferably be placed underground. However, where overhead electrical transmission lines are used, they would be installed and managed in accordance with Essential Energy (2012) *CEOP8008 Vegetation Management Plan*;
- *AS/NZS 1596 - 2008 The Storage and Handling of LP Gas* would be followed for bottled gas installation and maintenance with metal piping to be used;
- there would be at least 10 m between fixed gas cylinders and flammable materials;
- shielding would be placed on the side of the cylinders which face potential fires; and
- release valves on gas cylinders that are close to buildings would be directed away from the building and at least 2 m from combustible material; metal connections would be used.

23.4.4 Access

Internal roads would be designed in accordance with the following PBP guidelines:

- there would be a minimum vertical clearance of 4 m to any overhead obstructions including branches;
- there would be a minimum carriageway of 4 m with 1 m clearance on each side;
- there would be a maximum grade of 15° if sealed and less than 10° if unsealed;
- crossfall would not be more than 10°; and
- dead end roads are not recommended by the PBP guidelines; however, when they are unavoidable, turning circles would be provided with a minimum 12 m outer radius at the end of these roads.

23.4.5 Bushfire construction levels

All buildings would be designed in accordance with the general bushfire construction levels in *Australian Standard 3959 - 2009 Construction of Buildings in Bushfire Prone Areas* (AS 3959 - 2009).

23.4.6 Reducing risk of fire or explosion

The following measures would reduce the risk of a fire or explosion in the mining and infrastructure areas igniting a bushfire:

- refuelling would take place away from vegetation;
- fire extinguishers would be maintained in buildings, vehicles and refuelling areas;

- there would be no smoking in, or next to, vegetated areas;
- water carts would be made available to help with firefighting when required; and
- spill response kits would be available should there be a spill of flammable substances.

The following measures would be taken to reduce the likelihood of a bushfire or the consequences of a bushfire should one occur:

- a UHF/VHF communication system would enable rapid response to emergencies; and
- the RFS would be contacted if there is a fire.

23.4.7 Bushfire management procedures

Bushfire management procedures would be documented within an emergency response plan prepared prior to construction for the Balranald Project. Bushfire management procedures would include:

- contact person/details for emergency management;
- communication strategy for coordinated response to bushfires with the RFS;
- availability of suppression equipment;
- firefighting water supplies;
- storage of fuels and other flammable materials; and
- evacuation procedures for staff in case of bushfire emergency in accordance with the RFS *Guidelines for the Preparation of Emergency/Evacuation Plan*.

23.5 Conclusion

Parts of the project area contain bushfire prone land, including the processing area where habitable buildings would be constructed. Buildings in the processing area would be designed and constructed to protect human life and reduce the impact from a bushfire.

Management measures would be used to prevent a fire or explosion in the project area igniting a bushfire, reduce the severity of an existing bushfire through the provision of appropriately sized APZs and outline ways of fighting fires with mine resources.

Therefore, the risks associated with the Balranald Project being damaged by, igniting or contributing to the severity of a bushfire are expected to be appropriately managed.

24 Non-Indigenous heritage

24.1 Introduction

The SEARs for the Balranald Project require an assessment of impacts to historic heritage associated with the Balranald Project. The SEARs require the EIS to include:

> A historic heritage assessment (including archaeology) which must:
>
> - include a statement of heritage impact (including significance assessment) for any State significant or locally significant historic heritage items; and
> - outline any proposed mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures).

The SEARs list two best practice heritage publications to guide the historic heritage assessment, *The Australian International Council on Monuments and Sites Charter for Places of Cultural Significance* (also known as the *Burra Charter*, Australian ICOMOS 1999); and the *NSW Heritage Manual* (Heritage Office 2006).

A historic heritage assessment was undertaken by Landskape for the Balranald Project which addresses these requirements. The assessment is provided in Appendix R and summarised in this chapter.

24.2 Existing environment

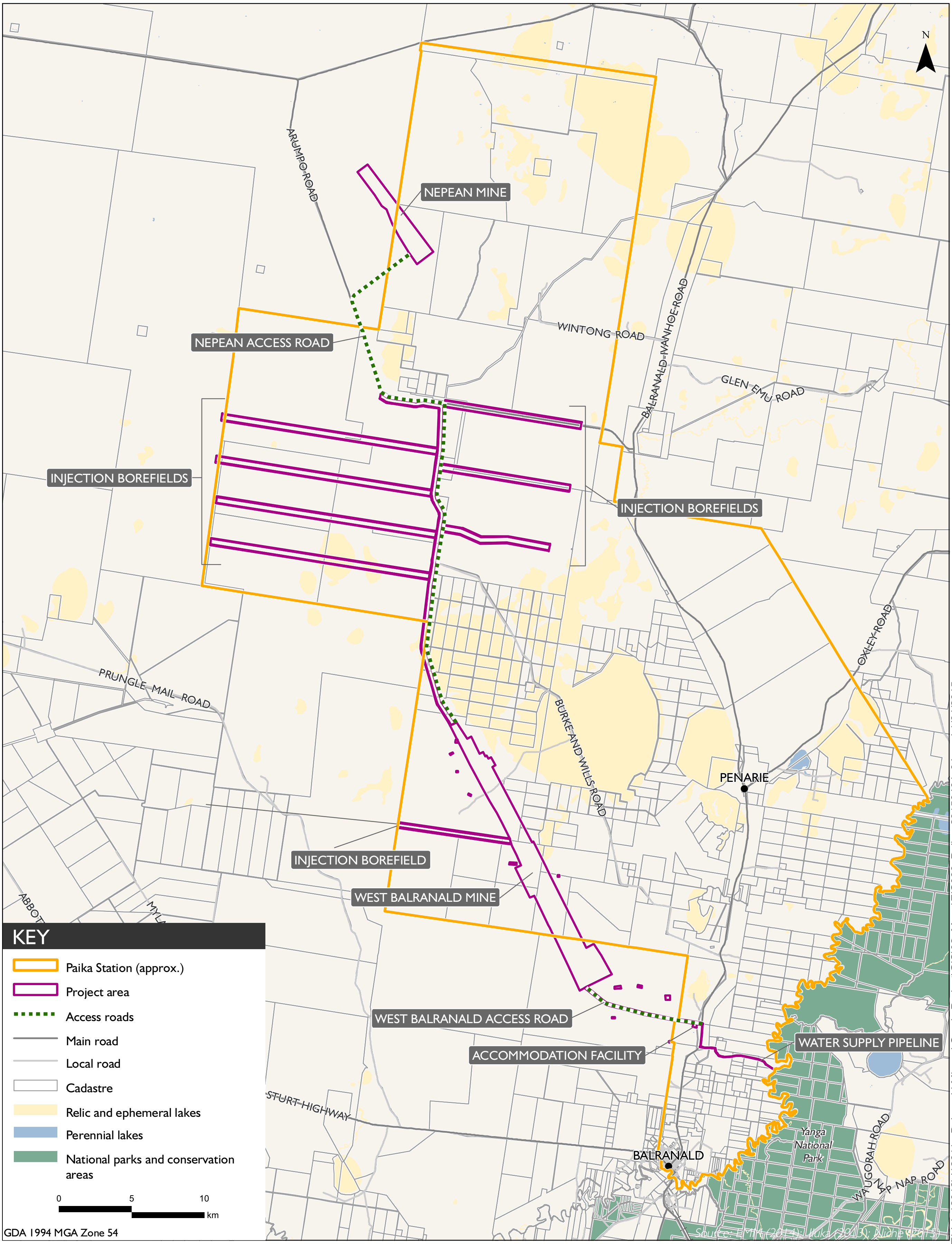
24.2.1 European settlement history

Captain Charles Sturt was the first European to visit the Lower Murrumbidgee River in 1830 and passed the site where Balranald town is now situated. Six years later, the Surveyor-General of NSW, Major Thomas Livingstone Mitchell, camped at what is now Balranald town during his 1836 survey expedition of south-eastern Australia. Mitchell was accompanied by an Aboriginal guide, Yuranigh, who preferred to be called John Piper. Two streets in Balranald town, Yuranigh and Piper streets, have been named in his honour.

In the following years, routes along the Murrumbidgee and Murray rivers were used to drive cattle overland from the colony of NSW to Adelaide. In the mid nineteenth century, pastoralists brought sheep to the region which led to reports of land being suitable for grazing. In March 1845, George Hobler established Paika Station, to the east of the project area, after claiming the northern reach of the Murrumbidgee River. It was the earliest and largest land holding within the region and covered the majority of the project area (see Figure 24.1).

Balranald town came into existence when peddlers, shepherds and itinerants crossed the Murrumbidgee River and established a settlement of simple, rough shelters. The first store and the Balranald Inn appeared in 1848. The town was named Balranald that year by George James MacDonald, the first commissioner for crown lands on the Lower Darling District after Balranald House, his birthplace on North Uist in the Outer Hebrides. At the time it was hoped that the town would become an important river port.

In 1850 a post office opened and the first district constable was appointed. The town was laid out and gazetted in 1851.



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The boundary of Paika Station

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Figure 24.1

The Darling Pastoral District was established in 1847. William Charles Wentworth took up the Paika lease, encompassing most of the project area. By 1851, Paika carried 11,000 sheep. The Victorian Exploring Expedition, led by Robert O'Hara Burke, with third in command William John Wills, passed through Balranald town in 1860 (Feldtmann 1976). Burke and Wills camped at Balranald town on 15 and 16 September 1860 before heading north to Paika station.

With land reforms, including the passing of the *Crown Lands Act 1881* , most of the old pastoral holdings including Paika were reallocated as WLLs in 1886 in an attempt to break the domination of land tenure by a few wealthy individuals. However this failed to stop the establishment of pastoral agglomerations including Peter McPherson's sons who took up some 194,884 acres over the project area, now Tin Tin, Karra and Paika stations. The remainder of the project area was covered by WLLs held by multiple title holders.

After World War One, sections of Paika Station near Pitarpunga Lake were subdivided into small allotments as part of a soldier settlement scheme, and now form part of Tin Tin Station.

24.2.2 Historical sites and structures

The types of historical heritage sites and structures that occur in south western NSW include:

- pastoral sites which relate to the arrival of European graziers and associated industries from the second half of the nineteenth century, including old homesteads and associated structures such as work sheds, shearing sheds, labourers quarters and surveys markers;
- historically significant commercial, public and residential buildings from the nineteenth and early twentieth century's, including railway stations, municipal halls, churches, libraries, schools and courthouses, parks, gardens and cemeteries including the monuments, grave markers; and
- significant transport sites, including small bridges made from River Red Gum timber or calcrete cobbles, shipping sites and associated wrecks of old boats and barges, wharves, jetties, ferry and punt landings, historic mileage markers and navigation markers along the Murray, Murrumbidgee and Darling rivers.

A review of the National Heritage List, NSW Heritage Council State Heritage Register (SHR) and the Balranald LEP was undertaken. There are no registered historic heritage sites in the project area. The closest historical feature on the National Heritage List and SHR is the WLRWHA which is located approximately 23 km north-west of the Nepean mine. Willandra Lakes' historical values are identified on the SHR as owing to being part of early European inland exploration (the Burke and Wills expedition) and development of the pastoral industry in south western NSW. Willandra Lakes also has significance for continuous human occupation of the area for the past 40,000 years, and has Pleistocene archaeological value for its contribution to the significant understanding of early cultural development in the region.

The closest historic site on the Balranald LEP is the Balranald Fire Station in Market Street, Balranald, approximately 13 km south of the project area.

24.3 Impact assessment

24.3.1 Methodology

A general predictive model examining possible heritage sites was formulated from relevant historical data along with topographical and geological maps to identify landscapes with the potential to contain archaeological sites. The predictive model for historic heritage in the region indicates that sites of significance would relate to early pastoral activities of the late nineteenth century or the first half of the twentieth century. Site types that have the potential to occur included dwellings and outbuildings, discarded farm machinery and blazed survey marks.

The probability of encountering historic sites in the project area is considered low, given that it does not encompass any current homesteads. Additionally, examination of historic pastoral maps did not reveal any previous pastoral homesteads in the project area. A field inspection of the majority of the project area was undertaken on 19 to 20 April 2011 and 13 February 2012 to complement the predictive model.

24.3.2 Survey results

No historic heritage sites were observed in the project area during the field surveys. The current landholder of Tin Tin Station identified the inferred path of the 1860 Burke and Wills expedition and an earthen water supply channel built by Alan and Walter McPherson in the 1890s, as features of historic interest; however, both are located outside the project area.

24.3.3 Impact assessment

Predictive modelling derived from desktop review, complemented by field surveys of the project area suggests that there is a low potential for significant historic heritage to occur in the project area. Therefore, no impacts to historical heritage are expected for the Balranald Project.

Potential impacts to the WLRWHA are addressed in Chapter 14.

24.4 Management and mitigation

As there are no historic heritage sites or values predicted to be impacted by the Balranald Project, no management or mitigation measures are proposed.

However, if historic heritage object(s) are uncovered during the construction and operational phases, all works would halt in the immediate area to prevent any further impact. A suitably qualified archaeologist would be contacted to determine the significance of the object(s). Any new object(s) would be registered with OEH and BSC including details of their proposed management.

24.5 Conclusion

The historic heritage assessment conducted by Landskape did not identify any historic heritage sites or values with potential to be impacted by the Balranald Project. Accordingly, no management or monitoring measures are required in respect of historic heritage. Notwithstanding contingency measures would be in place for the unlikely event that any historic heritage object(s) is identified during construction and operation of the Balranald Project.

25 Visual

25.1 Introduction

The SEARs for the Balranald Project require an assessment of its potential visual impacts. The SEARs state that this EIS must include:

> an assessment of the likely visual impacts of the development on private landowners in the vicinity of the development and key vantage points in the public domain, the temporary and permanent modification of the landscape during the various stages of the project (overburden dumps, bunds), and minimising the lighting impacts of the development.

The visual assessment and results are presented in this chapter.

25.2 Existing environment

25.2.1 Visual character

As discussed in Chapter 3, the landscape of the project area is generally flat. There are areas surrounding the project area with high scenic view quality, including areas with natural features such as:

- the WLRWHA which is located about 23 km north west of the Nepean mine footprint;
- Mungo National Park which is located about 19 km north west of the Nepean mine footprint; and
- Yanga National Park and the Murrumbidgee River which are located about 10 km south-east of the West Balranald mine footprint.

Visual features in the project area at the West Balranald mine include mallee dunes in the south of the deposit and relatively flat areas comprising dry relic lake beds to the north. The Nepean mine forms part of a large area of linear dune mallee.

Land uses in the immediate vicinity of the project area are primarily agricultural, and include sheep and cattle grazing on saltbush plains and broadacre grain crops. Other land uses include tourist accommodation (at Paika Station, Southern Mallee Conservation Areas), gypsum mining and charcoal production (using cleared mallee scrub). These land uses are interspersed with areas of native vegetation; primarily mallee scrub that is subject to environment and ecological conservation.

The only township or settlement in proximity to the Balranald Project is Balranald town located about 12 km south-east of the West Balranald mine footprint.

25.2.2 Assessment locations

Assessment locations surrounding the Balranald Project, being those receptors who may be impacted by changes to the visual environment, include:

- Balranald town;
- assessment locations being buildings (including homesteads/dwellings, sheds, shearers quarters and other outbuildings) on private properties located sparsely across the region;

- visitors to conservation areas including the WLRWHA, Mungo National Park and Yanga National Park; and

- road users (people in vehicles) whose intermittent views may be impacted by the Balranald Project while driving through the area.

Assessment locations can be seen in Figure 25.1.

As described in Chapter 3, the identification of assessment locations was largely based on aerial photography interpretation, with ground-truthing of structures closer to the project area.

25.2.3 Changes to existing visual character

Changes to the landscape can alter the visual character of an area. Alterations can result from vegetation removal, overburden stockpiling, landform modification, modification to natural drainage patterns and the placement of artificial elements into the landscape (ie buildings or structures).

Changes to the landscape can be considered to be positive or negative depending upon the perception of the receptor (ie one receptor or person my perceive a new building or structure in the landscape as a positive visual impact while another receptor may perceive it be a negative visual impact). Generally, changes to landscapes associated with mining (due to overburden stockpiling and permanent alterations to the natural landform) are perceived to be negative, and this visual assessment has been undertaken on this basis.

Changes to the landscape can also be temporary (ie short-term) or permanent. Potential changes to the existing visual character of the project area associated with the Balranald Project would be predominantly temporary. Temporary changes would be associated with infrastructure required during operations that would be removed or decommissioned at various stages during and after the mine life (eg stockpiles, site services, buildings, roadways, car parks and hardstand areas, water management system, telecommunication towers and lighting). With the exception of infrastructure that would be used by landholders post mining (such as roads and dams), all infrastructure would be removed as part of site decommissioning and closure. Any infrastructure that remains would largely be located at natural ground levels and would not represent significant landform alterations.

Some permanent changes would result from the development of the final landforms that would remain post mining, including removal of mallee vegetation and a final void. The nature of the change would vary according to the rehabilitation status both during and post-mining. Final landforms associated with a rehabilitated final void are described in detail in the Rehabilitation and Closure Strategy contained in Appendix M. This states that the proposed closure and rehabilitation strategy for the Balranald Project includes:

- a final landform design for the West Balranald and Nepean mines which replicates the original landform as much as possible;

- establishment of native vegetation communities (predominantly chenopod shrublands) suitable for intermittent and low intensity grazing uses; and

- provision of a final void at the northern extent of the West Balranald mine only (ie no void at the Nepean mine) which would remain above the groundwater table.

Importantly, the design of the final void at the West Balranald mine would not contain a permanent water body (surface water would only temporarily pond after significant and/or prolonged rainfall events) and rehabilitation will enable post establishment of the native vegetation communities and agricultural practices.

25.3 Impact assessment

25.3.1 Method

Due to the project area being generally flat, the distance between the Balranald Project and sensitive receptors varies greatly. Generally, as the distance increases between the Balranald Project and the sensitive receptors, colour and texture would increasingly vary and be seen as grouped elements before diminishing. The further the sensitive receptors are away from the project area, the more the view would be dominated by the natural landscape. Receptors beyond 10 km were not considered as the visibility of the Balranald Project diminishes with distance, and views from distances of greater than 10 km are considered to be negligible.

Given the flat nature of the area, there would generally only be the potential for views of the larger overburden stockpiles, the processing plant and the telecommunications towers. No views over and into the project area would be possible from sensitive receptors or vantage points.

A qualitative analysis was undertaken for the visual assessment of the Balranald Project. The tasks undertaken included:

- undertaking a viewshed analysis using GIS to calculate the visibility of the overburden stockpiles, processing plant and accommodation facility for each of the three conceptual mine layout plans, Year 1, Year 4 and Year 8, at any point in surrounding the project area;

- identification of representative viewpoints (based on assessment locations identified for the noise and air quality assessments) to assess potential impacts on rural homesteads;

- assessment of the significance of the potential visual impact of the Balranald Project from identified sensitive receptors; and

- provision of mitigation measures, if found to be necessary, that could be implemented to reduce visual and lighting impacts.

Visual impacts were considered in terms of the view type/context and the visual absorption capacity (VAC) of a view. View type/context describes the existing landscape character, particularly the topography and screening provided by vegetation or other elements. VAC is a measure of the landscapes ability to absorb development without a significant change in the character and measured as either low, moderate or high. A low VAC would represent a modification/addition to the landscape area which would result in high visual contrast and a low level of visual integration with the surrounding landscape. A high VAC would represent a modification/addition to the landscape area which would result in minimal visual contrast and a high level of visual integration with the surrounding landscape.

The viewshed analysis did not consider injection borefield infrastructure or the telecommunication towers. Injection borefield infrastructure is generally low in height and, with the exception of travellers on Burke and Wills and Arumpo roads, is unlikely to be visible from any sensitive receptors, including those assessment locations located near the borefield injection areas (ie assessment locations R13, R19, R32 and R406). Given the nature of the telecommunication towers (tall lattice structures), a viewshed analysis does not accurately represent the locations from where a tower may be visible. Due to the height of the towers, the results of a viewshed analyse would indicate towers are visible from large distances, where in reality they are only visible from closer distances. Accordingly, a separate impact assessment was undertaken for the telecommunication towers (refer to Section 25.4.3).

i Viewpoints

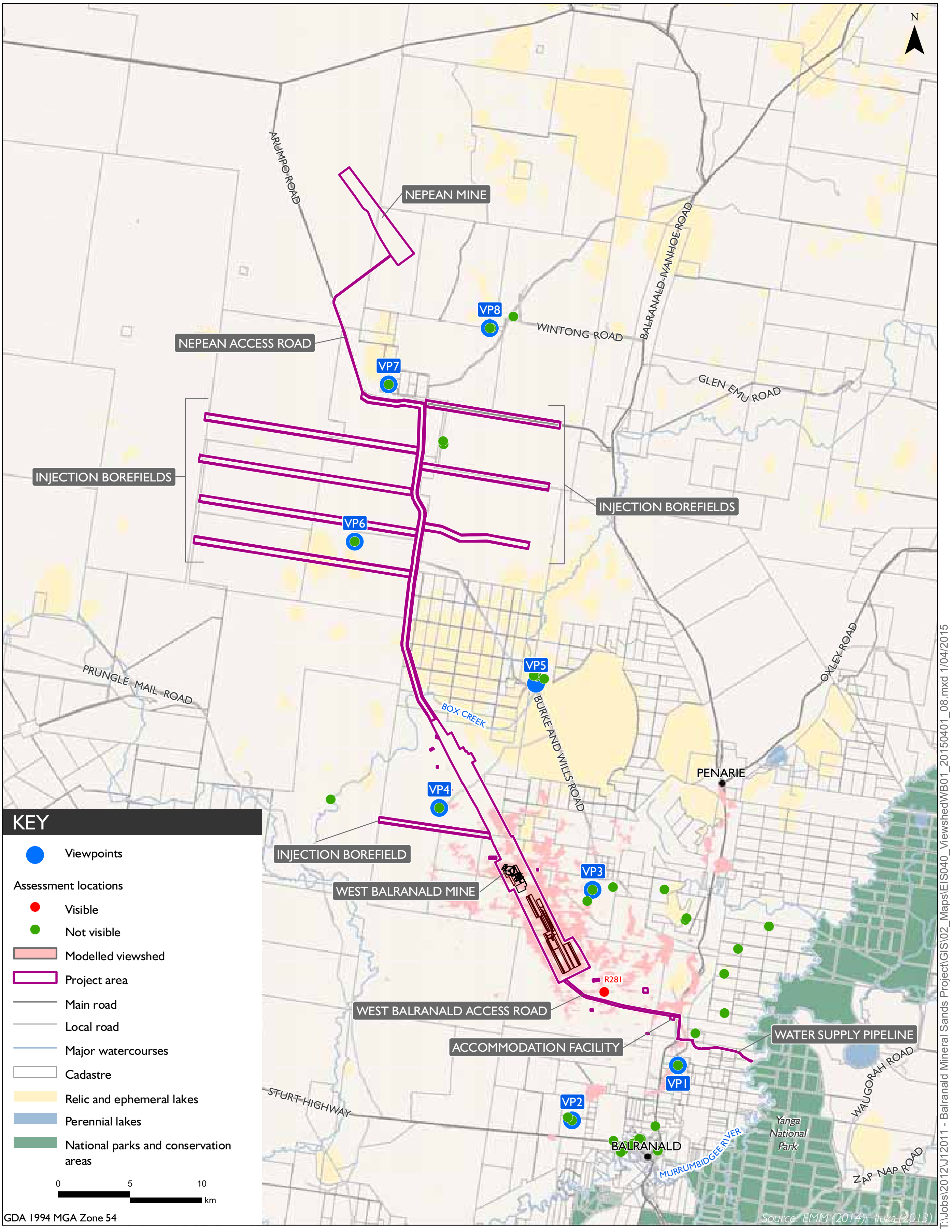
Eight representative viewpoints were selected to illustrate views around the project area.

The eight representative viewpoints are located within 10 km of the project area. The viewpoints are shown in Figures 25.1 to 25.4 and are referred to as:

- VP1 – located 5 km to the south-east of the West Balranald mine and represents assessment locations R45, R54, R57 and R108;
- VP2 – located 6.3 km south of the West Balranald mine and represents assessment locations R40 and R41;
- VP3 – located 1.8 km east of the West Balranald mine and represents assessment locations R7, R36 and R92;
- VP4 – located 1.6 km west of the West Balranald mine and represents assessment location R5;
- VP5 – located 6 km north-east of the West Balranald mine and represents assessment locations R402, R403 and R405;
- VP6 – located 13 km north-north-west of the West Balranald mine and represents assessment location R19;
- VP7 – located 6.2 km south- of the Nepean mine and represents assessment location R13; and
- VP8 – located 4.8 km south of the Nepean mine and represents assessment location R11, R12 and R419.

Transient viewpoints have also been considered along roads that may have the public using them. All roads are likely to have a combination of tourists, locals and trucks. Transient viewpoints identified are:

- Balranald-Ivanhoe Road located to the south-east of the West Balranald mine;
- Sturt Highway located to the south, and south-west of the West Balranald mine;
- Burke and Wills Road located generally to the east of the West Balranald mine; and
- Arumpo Road located generally to the west of the Nepean mine.



Viewshed analysis - Year 1, West Balranald mine

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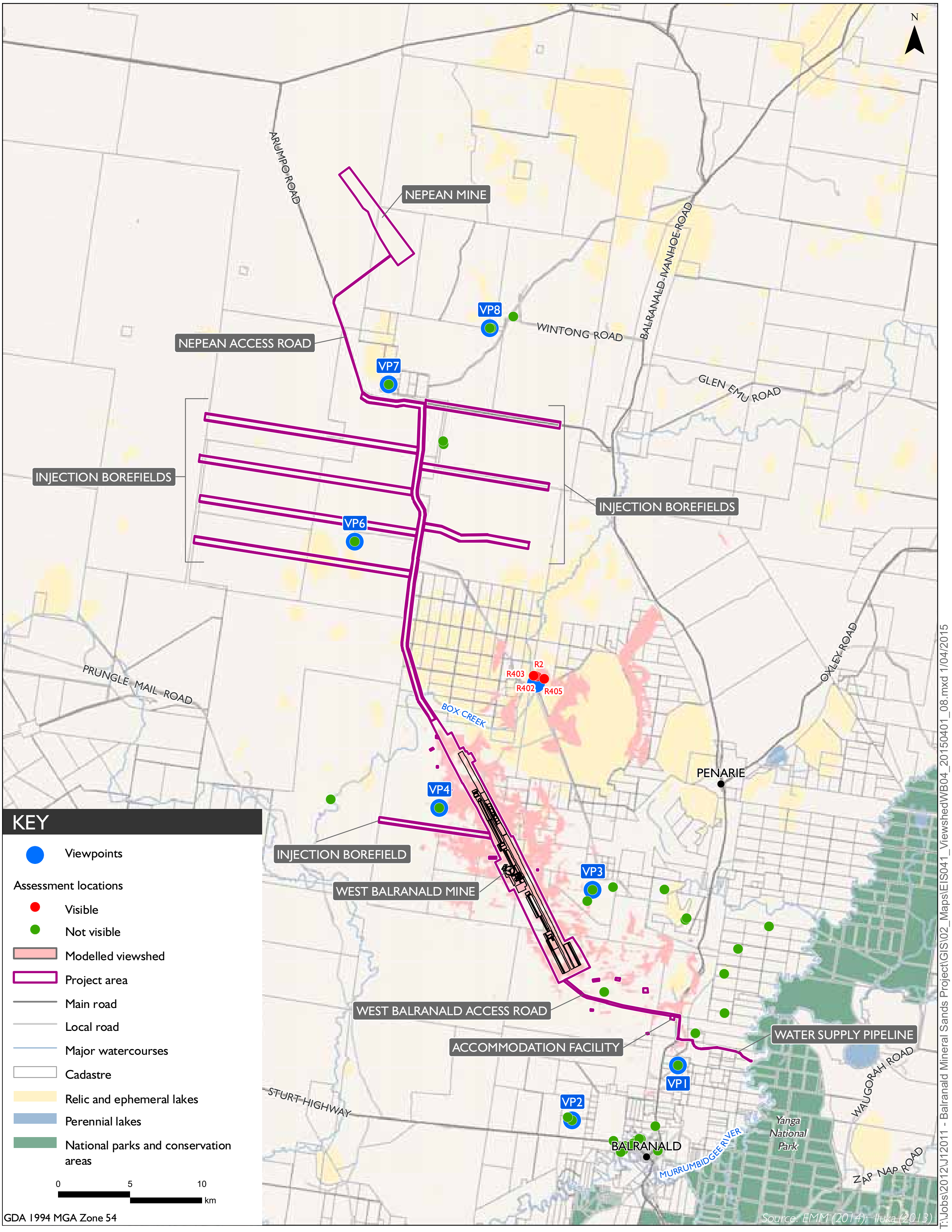
Figure 25.1



EMM
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Viewshed analysis - Year 4, West Balranald mine

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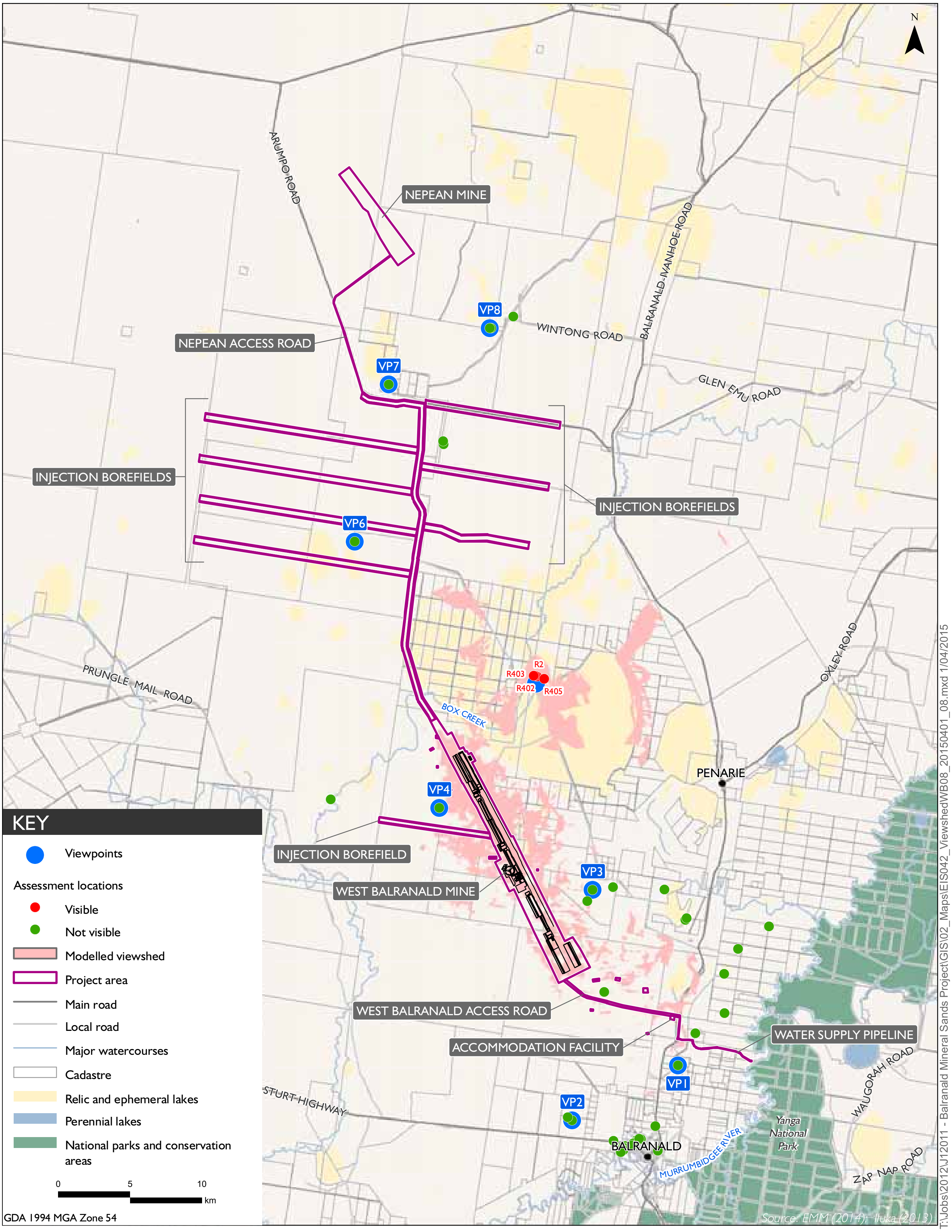
Figure 25.2



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Viewshed analysis - Year 8, West Balranald mine

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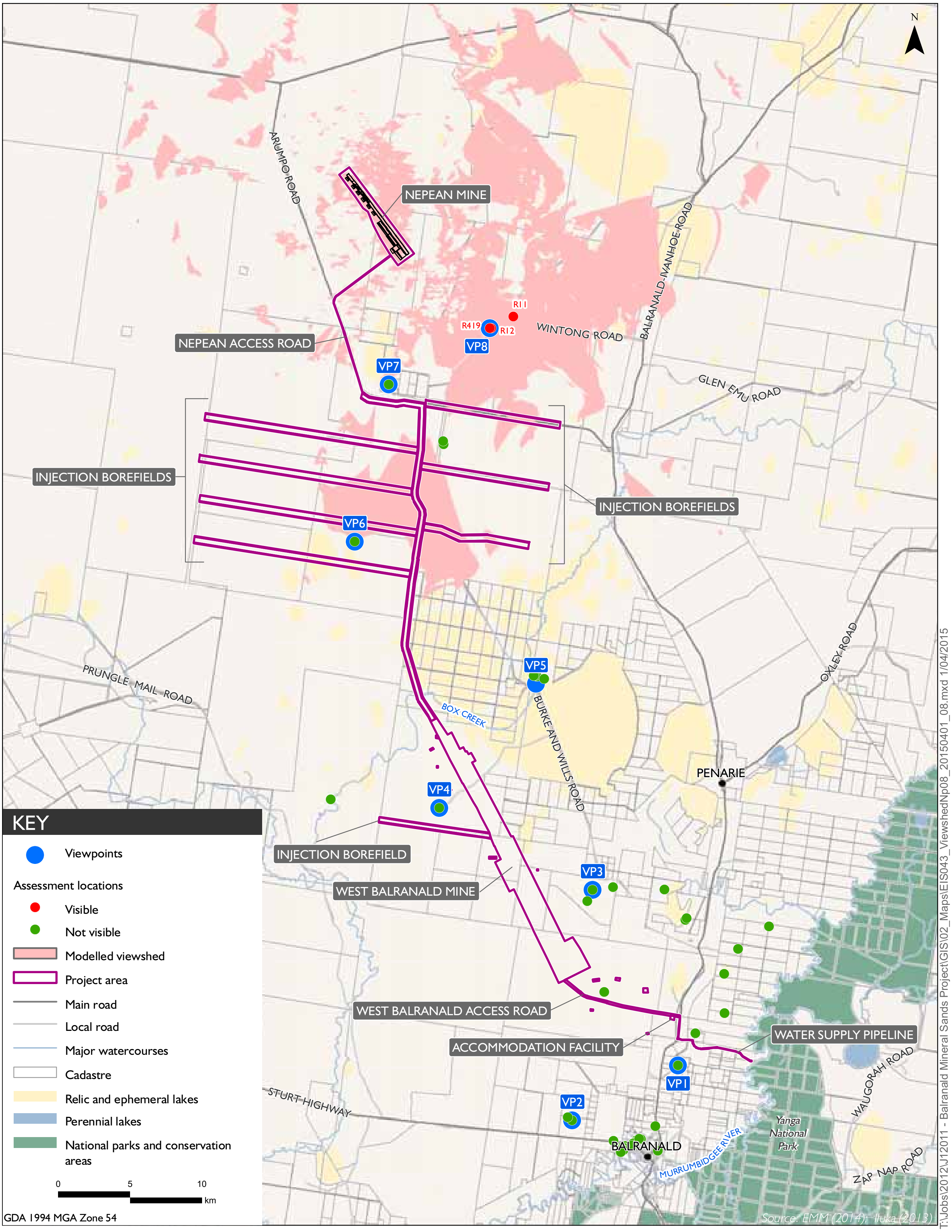
Figure 25.3



EMM
ILUKA

Viewshed analysis - Year 8, Nepean mine

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Figure 25.4

ii Viewshed analysis

A viewshed analysis was undertaken using spatial analysis in GIS. It identifies the likely extent of visibility of a built structure or object within a given area. Using a digital elevation model (DEM) within the area of interest, along with other parameters such as the curvature of the earth and the height of the built structure or object, it is possible to predict whether the structure or object has a line of sight with sensitive receptors.

Each of the stage plans of the project (Years 1, 4 and 8) were modelled separately. The DEM used in the analysis was based on an ortho-rectified aerial image captured in January 2012. Data inputs for the viewshed analysis included the infrastructure (particularly the processing plant) and the overburden stockpiles for Years 1, 4 and 8 for West Balranald mine, and the overburden stockpiles at Nepean mine for Year 8. The outputs produced from the analysis were used to identify which of the representative viewpoints had a line of sight to the mining operations.

The top of the processing plant elevation was assumed to be 15 m above ground level and the overburden stockpile elevations were set at 15 m, the maximum height of the stockpiles. Many of the stockpiles would have lower heights in the order of 10 m, 9 m, 5 m and 2 m, which would reduce their visibility. The observer height was set at 1.7 m as the average eye-level. As stated before, curvature correction was applied to the DEM surface to account for the curvature of the earth.

This viewshed analysis does not take into account the obstruction of vegetation, buildings or other objects. In reality, the mine infrastructure would not be visible to all areas classed as visible in the analysis due to these obstructions. In addition, the analysis doesn't account for the distance of the structure, how it is lit, its size and other environmental conditions such as haze (ie assumes 'worst case scenario' with a unobstructed line of sight to the site from each vantage point).

25.3.2 Results

i Visual absorption capacity

Due to the topography of the project area, the VAC is considered to be high and comparable for all representative viewpoints and transient receptors. Visible features such as the processing plant and overburden stockpiles are unlikely to contrast significantly with the colour tones of the surrounding landscape. The landscape surrounding the project area is largely flat while the processing plant and overburden stockpiles would be a maximum of 15 m high. As a result, although the colours of the stockpiles would be similar to the background, the Balranald Project's visible mining operations would contrast with the surrounding area.

ii Viewshed analysis

The results of the viewshed analysis show that the viewshed of West Balranald mine is relatively limited and generally concentrated within an area about 5 km east and west of the active mining area. Some views are possible of the West Balranald mine during all mine years to the south-east, generally between the mine footprint and Balranald-Ivanhoe Road. Also, during Years 4 and 8, views of West Balranald Mine are possible further west at locations between Burke and Wills Road and Balranald-Ivanhoe Road. The West Balranald Mine cannot be seen from Balranald town or nearby conservation areas.

The results also show that the viewshed of Nepean mine is relatively large in comparison to West Balranald mine. The viewshed extends to areas about 7 to 10 km surrounding the mine, particularly to the south, south east and east. This is largely due to the elevation of the mine which is generally higher than the surrounding areas, particularly the south, south east and east. Although the results show the Nepean mine would be visible for a large area, the limitations of the analysis must be taken into account, most importantly, the Balranald Project's visual features diminishing as distance increases and other landscape features such as vegetation, not considered in the model.

The results of the viewshed analysis are shown in Figures 25.1 to 25.4.

iii Balranald town

The viewshed analysis shows that the Balranald Project would not be visible from Balranald town. Elements of the West Balranald mine (overburden stockpiles and the processing plant) are likely to only be visible from isolated locations about 4 km north of the town.

iv Rural homesteads

As previously stated, eight representative viewpoints were selected to assess potential visual impacts from the larger number of rural homesteads located around the project area.

The results from each viewpoint for the representative mine years are discussed in Table 25.1. It should be noted that the 'likely visible' column provides an indication of whether the processing plant or overburden stockpiles are likely to be visible given the distance and existing vegetation screening as the viewshed analysis doesn't take these into account.

Table 25.1 Visual impact results

	Distance from viewpoint	Visibility (Figures 26.1 to 26.4)	Likely visible	Visual impact
VP1				
Processing plant	18 km	No	No	The viewshed analysis shows that the processing plant and overburden stockpiles would not be visible for all mine years. The high likelihood that vegetation screening would occur between the two points, large distance and high VAC mean it is unlikely that the accommodation facility, processing plant and overburden stockpiles would have a visual impact on sensitive receptors represented by VP1. It is likely that during night operations the overburden stockpiles would have some plant and equipment lit and operating on them. This could produce a glow (or light haze) from the mine that may be visible at this viewpoint, however as there is no direct line of sight, impacts are predicted to be negligible.
Active mining area:				
Year 1	8.4 km	No	No	
Year 4	17.4 km	No	No	
Year 8	23.8 km	No	No	

Table 25.1 Visual impact results

	Distance from viewpoint	Visibility (Figures 26.1 to 26.4)	Likely visible	Visual impact
VP2				
Processing plant	17.5 km	No	No	The visual impact at VP2 would be the same as the impact at VP1.
Active mining area:		No	No	
Year 1	8.6 km	No	No	
Year 4	17.6 km	No	No	
Year 8	23.5 km	No	No	
VP3				
Processing plant	6 km	No	No	Despite the relative close proximity of VP3 to West Balranald mine, the viewshed analysis shows that the processing plant and overburden stockpiles are unlikely to be visible from VP3 during all years of mining (Years 1, 4 and 8). The high likelihood that vegetation would screen operations from this viewpoint and the high VAC, mean the likelihood for any visual impact is further reduced. However, it is likely that lighting from plant and equipment on overburden stockpiles and at the processing plant would be visible at night from this viewpoint. This is considered to have a moderate impact. Mitigation measures are recommended in Section 25.4 to reduce this impact.
Active mining area:				
Year 1	4.1 km	No	No	
Year 4	4.8 km	No	No	
Year 8	10.5 km	No	No	
VP4				
Processing plant	6.5 km	No	No	Similar to VP3, the viewshed analysis shows that despite the relative close proximity of VP4 to West Balranald mine, the processing plant and overburden stockpiles are unlikely to be visible from this viewpoint during all years of mining (Years 1, 4 and 8), particularly Year 1. However, again, it is likely that lighting from plant and equipment on overburden stockpiles and at the processing plant would be visible at night from this viewpoint. This is considered to have a moderate impact. Mitigation measures are recommended in Section 25.4 to reduce this impact. Some infrastructure associated with the injection borefields may be visible from VP4, however, given the scale of this infrastructure, no significant impacts are anticipated.
Active mining area:				
Year 1	14 km	No	No	
Year 4	4.2 km	No	No	
Year 8	2.8 km	No	No	

Table 25.1 Visual impact results

	Distance from viewpoint	Visibility (Figures 26.1 to 26.4)	Likely visible	Visual impact
VP5				
Processing plant	14 km	Yes	Yes	The viewshed analysis shows that the processing plant would visible from VP5. Due to a high VAC, existing vegetation screening and large distance, it is unlikely though that the processing plant would have a visual impact. During Years 4 and 8 mining operations at West Balranald mine would be approximately 7 km and 9 km respectively away which represent the closest operations for this representative viewpoint. It is unlikely that visual impacts would be significant, again due to the high VAC, existing vegetation screening and distance. Mine year 1 is too far away to be visible from VP5. During Years 4 and 8, limited plant and equipment lighting on overburden stockpiles may be visible on the horizon creating a visible glow or light haze. This is expected to have a low impact.
Active mining area:				
Year 1	20 km	No	No	
Year 4	10 km	Yes	No	
Year 8	6.9 km	Yes	Yes	
VP6				
Processing plant	25.5 km	No	No	The viewshed analysis shows that operations during Year 8 at the Nepean mine may be visible at VP6. However, due to the distance (13 km) between VP6 and mining operations and high VAC, it is likely the Project would have a negligible visual impact due to the significant viewing distances. The processing plant and overburden stockpiles are considered to be too far away to have a lighting impact on VP6. Some infrastructure associated with the injection borefields may be visible from VP6, however, given the scale of this infrastructure, no significant impacts are anticipated.
Active mining area:				
Year 1	33.1 km	No	No	
Year 4	22.2 km	No	No	
Year 8	15.6 km	No	No	
Year 8 Nepean	20.1 km	No	No	

Table 25.1 Visual impact results

	Distance from viewpoint	Visibility (Figures 26.1 to 26.4)	Likely visible	Visual impact
VP7				
Processing plant	36 km	No	No	The processing plant at the West Balranald mine would not be visible from VP7 for mining Years 1, 4 and 8. Although the viewshed analysis has shown that no mining operations would be visible from the Balranald Project, VP7 is the second closest receptor to the Nepean mine and was therefore considered. While mining operations may not be visible from VP7, the Nepean access road is located about 1 km to the south and 2 km to the west of the viewpoint. It is unlikely the trucks would be visible however the road to the west would be unsealed, and therefore it is possible that dust may be visible intermittently. These visual impacts are considered low and air quality impacts are addressed in Chapter 10. During Year 8, limited plant and equipment lighting on overburden stockpiles from the Nepean mine may be visible on the horizon creating a visible glow or light haze. This is expected to have a low impact. Some infrastructure associated with the injection borefields may be visible fromVP7, however, given the scale of this infrastructure, no significant impacts are anticipated
Active mining area:				
Year 1	42.3 km	No	No	
Year 4	31.8 km	No	No	
Year 8	25.5 km	No	No	
Year 8 Nepean	9 km	No	No	
VP8				
Processing plant	38 km	No	No	VP8 is representative of the closest receptors to the Nepean mine. Overburden stockpiles at the Nepean mine would likely be seen from VP8 in Year 8. Existing vegetation screening, the high VAC, and distance mean that VP8 is likely to experience a low visual impact. During Year 8, limited plant and equipment lighting on overburden stockpiles from the Nepean mine may be visible on the horizon creating a visible glow or light haze. This is expected to have a low impact.
Active mining area:				
Year 1	44.6 km	No	No	
Year 4	34.8 km	No	No	
Year 8	29.1 km	No	No	
Year 8 Nepean	8 km	Yes	Yes	

v Conservation areas

The viewshed analysis shows that the Balranald Project would not be visible from any surrounding conservation areas, including the WLRWHA, Mungo National Park and Yanga National Park. Given the distances of the West Balranald and Nepean mines from these conservation areas (about 23 km from the WLRWHA, 19 km from Mungo National Park and 10 km from Yanga National Park), it is unlikely that these areas would be impacted by visible glow or light haze from mining operations.

vi Road users

a. Balranald-Ivanhoe Road

The Balranald-Ivanhoe Road is located to east of the Balranald Project. It is a 100 km/h, two lane, two way public road. This road is used by people travelling between the towns of Balranald, Ivanhoe, Cobar and Menindee, tourists travelling to Mungo National Park, and to access local properties.

The viewshed analysis shows that the West Balranald mine would only be visible at a few locations on the Balranald-Ivanhoe Road between Balranald town and its intersection with the West Balranald access road. It also shows that the Nepean mine would only be visible at one 2 km section of the Balranald-Ivanhoe Road, immediately west of the mine. At these locations, it is likely that only the overburden stockpiles would be visible.

Vegetation between the road and the project area, particularly road-side vegetation, would interrupt the line of sight between the stockpiles and the road. Due to the large distance between the road, the high VAC and intermittent views of the stockpiles while driving, it is likely that the visual impact would be low.

During all years (Years 1, 4 and 8), limited plant and equipment lighting on overburden stockpiles from the West Balranald and Nepean mine may be visible on the horizon creating a visible glow or light haze. This is expected to have a low impact.

The accommodation facility would be constructed adjacent to the Balranald-Ivanhoe Road, at its intersection with the West Balranald access road. It has been sited in an area that is screened by a dense stand of roadside vegetation. Accordingly the accommodation facility would not be visible from Balranald-Ivanhoe Road.

b. Sturt Highway

The Sturt Highway is located to the south and south-west of the West Balranald mine and is part of the main highway route between Sydney and Adelaide. Outside of Balranald town, the Sturt Highway is a 110 km/h, two lane, two way national highway.

The viewshed analysis indicates that the Balranald Project would not be visible from Sturt Highway. There is one location about 7 km west of Balranald town that may provide an opportunity to view overburden stockpiles during Year 1 of operations at the West Balranald mine, however, actual views are unlikely due to existing vegetation screening, distance and the intermittent nature of views from the highway.

c. Burke and Wills and Arumpo roads

Burke and Wills and Arumpo roads are unsealed two way public roads that generally run parallel to the project area. Burke and Wills Road runs to the east and generally parallel to the West Balranald mine. Arumpo Road generally runs to the west and parallel with the Nepean mine. Burke and Wills Road intersects with Arumpo Road immediately south of Nepean mine. Both roads, via the Balranald-Ivanhoe Road, provide access to Mungo National Park.

A 22 km section of Burke and Wills Road and Arumpo Road would be used as part of the Nepean access road to transport extracted ore from the Nepean mine to the processing area at the West Balranald mine.

The viewshed analysis indicates that, like Balranald-Ivanhoe Road, the West Balranald mine would only be visible at a few locations on Burke and Wills Road in Years 1, 4 and 8. It won't be visible at any time from Arumpo Road. However, the Nepean mine in Year 8 would be visible at one long (9 km) section of Burke and Wills Road south of its intersection with Arumpo Road, and small sections of the Arumpo Road. At these locations, it is likely that the overburden stockpiles would be visible.

Vegetation between the road and the project area, particularly road-side vegetation would interrupt the line of sight between the stockpiles of Nepean mine and the Burke and Wills and Arumpo roads. Due to the distance between the roads, the high VAC and intermittent views of the stockpiles while driving; it is likely that the visual impact would be low.

During all years (Years 1, 4 and 8), limited plant and equipment lighting on overburden stockpiles from the West Balranald and Nepean mine may be visible on the horizon creating a visible glow or light haze. This is expected to have a low impact.

Some infrastructure associated with the injection borefields would be visible from both Burke and Wills and Arumpo roads, however, given the scale of this infrastructure, no significant impacts are anticipated.

25.3.3 Telecommunications towers

Two telecommunications towers are proposed for the Balranald Project; a 70 m self-supporting lattice tower located 500 m from the processing area at West Balranald mine, and a 50 m lattice mast supported by guy wires located at Nepean mine. The 70 m tower would be erected during the initial construction phase and the 50 m mast would be erected before the commencement of mining at Nepean mine. Both would be decommissioned following completion of mining.

A study conducted in the United States in 2013 by the US Department of the Interior (Bureau of Land Management) undertook observations of electric transmission facilities to identify the maximum distances at which the transmission facilities are visible. Observations were undertaken of different facilities, in differing landscape settings in western states, under various lighting and weather conditions, and in different seasons. Two facilities studied included large lattice towers (ie 500 kV towers) and smaller lattice towers (ie 230 kV towers). A large lattice tower (ie 500 kV tower) can be seen in Photograph 25.1.

The study found that, while large lattice towers were visible at distances up to about 16 km in flat areas, they were generally only noticeable to casual observers at distances of about 8 km. For the smaller lattice towers, the study found that they were visible at distances up to 13 km, but only noticeable to casual observers at distances of about 2.4 km.

Photograph 25.1 550 kV tower in the US

The lattice towers proposed for the Balranald Project are much smaller than the 500 kV and 230 kV towers studied by the US Department of the Interior. Therefore, it would be expected that the visibility distances of the lattice towers would be much smaller than those of the 230 kV towers.

The telecommunications tower at West Balranald mine would be about 6 km from the nearest assessment location and about 7 km from the nearest road (Burke and Wills Road). The telecommunications tower at the Nepean mine would be about 8 km from the nearest assessment location and about 4 km from the nearest road (Arumpo Road). Accordingly, given that these distances are greater than the visibility distances determined for the 230 kV towers, it is likely that the telecommunications towers at the West Balranald and Nepean mines would not be visible from any sensitive receptors.

The visibility of a lattice tower similar to that proposed at the Nepean mine can be seen in Photographs 25.2 and 25.3. These photographs show a lattice tower supported by guy wires near the project area adjacent to the Balranald-Ivanhoe Road. The photographs show that while the tower is noticeable in close proximity, its visibility greatly reduces the further a receptor moves away from the tower.

Photograph 25.2 **Telecommunications tower adjacent to Balranald-Ivanhoe Road (photograph taken about 1 km from tower)**

Photograph 25.3 **Telecommunications tower adjacent to Balranald-Ivanhoe Road (photograph taken about 1.2 km from tower)**

25.3.4 Cumulative impacts

No significant cumulative visual impacts (including potential night-lighting impacts) are anticipated from the potential concurrent operation of the Balranald Project and Cristal's Atlas-Campaspe Minerals Sands Project given the distance between the project areas (about 11 km from the Nepean mine) and the nature of development in that area.

25.4 Management and mitigation

Visual impacts are predicted to be predominantly negligible to low, largely due to the VAC of the existing landscape, the distance from which the visible elements would be observed, and the presence of existing vegetation that would provide screening and partial obstruction of views from observer locations. Lighting from plant and equipment on overburden stockpiles and at the processing plant would be visible at night from some viewpoints which could results in moderate impacts. To manage and mitigate lighting impacts, Iluka would implement the following measures:

- install directional light fittings in the processing area to minimise light spill;
- use of low wattage lighting;
- limit placement of lighting at the top of overburden stockpiles (at night), where safe and practical, to provide screening and limit light spill on top of overburden stockpiles; and
- progressive rehabilitation of disturbed areas to minimise the extent of, and views to, the most visually obtrusive elements in the project area.

25.5 Conclusion

The visual assessment for the Balranald Project considered potential visual impacts of the Project on surrounding sensitive receivers, including Balranald town, rural residences, conservation areas (WLRWHA, Munga National Park and Yanga National Park) and road users.

The assessment of potential impacts on buildings (assessment locations) surrounding the project area was assessed based on eight representative viewpoints surrounding both the West Balranald and Nepean mines. The visual assessment utilised a viewshed analysis using GIS to calculate the visibility of features in the Balranald Project for each of the three conceptual mine layout plans, Year 1, Year 4 and Year 8, at any point in surrounding the project area. Generally, visual and lighting impacts were considered to be negligible to low based on the distances between viewpoints and mining operations, and screening provided by existing vegetation.

Given the limitations of viewshed analysis to determine the visibility of lattice towers, an assessment was undertaken based on the results of a study determining visibility distance of towers in the United States. The results of this study indicate that the telecommunications towers at the West Balranald and Nepean mines would not be visible from any sensitive receptors.

A number of visual and lighting impact management measures would be implemented to mitigate and manage impacts during operation of the Balranald Project.